WOOD PIPE HANDBOOK

NATIONAL QUALITY NATIONAL

NATIONAL TANK & PIPE CO.
KENTON STATION
PORTLAND, OREGON

Every precaution has been taken to see that all information in this Handbook is correct; however, we assume no responsibility for errors.

A Handbook of Wood Pipe Practice

. . . in which are treated the engineering features involved in the design, erection, and operation of pipe lines. May it prove helpful to professional and business men alike whose responsibilities embrace the transportation of water.

NATIONAL QUALITY NATIONAL

National Tank & Pipe Company

DIVISION OF M AND M WOODWORKING COMPANY

2301 NORTH COLUMBIA BOULEVARD

PORTLAND, OREGON

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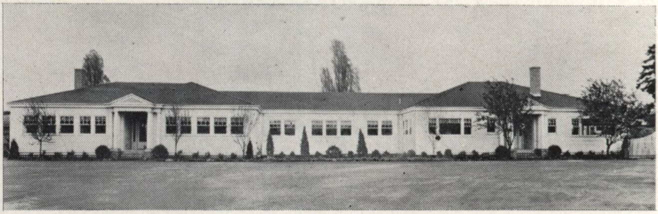

Home office building of National Tank & Pipe Company, Kenton Station, Portland, Oregon

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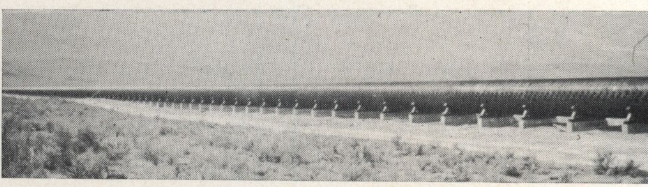


"National Quality" Wood Pipe

FOREWORD

"National Quality" wood pipe is being specified today for municipal water supply systems, power plants, irrigation projects, and by numerous industries because it makes a safe, durable, and economical installation.

"National Quality" wood pipe has:

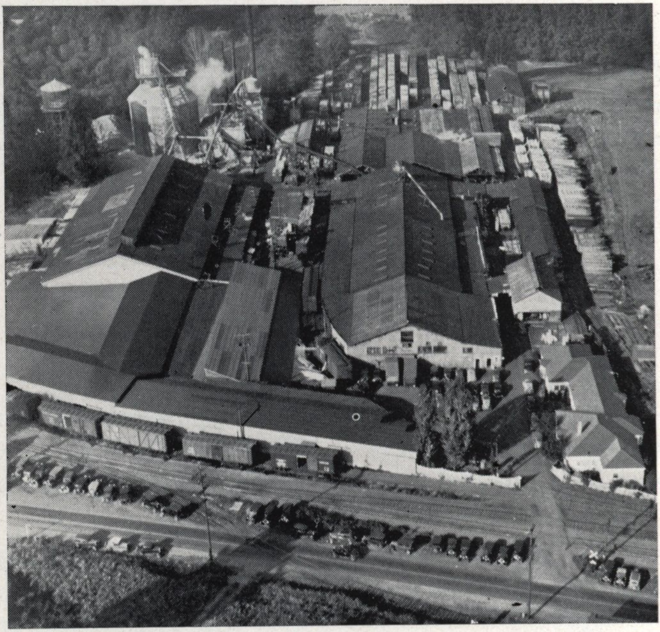
LOW COST
LONG LIFE
CLEANLINESS
ADAPTABILITY

It can truthfully be said, that under ordinary ranges of pressure, water can be delivered through wood pipe, year after year, for less money than through pipe made of any other material.

Under normal conditions "National Quality" wood pipe will give excellent service for 30 to 50 years without appreciable maintenance cost. The original cost of this pipe is so low that the saving made will more than cover all costs of replacement when it has outlived its usefulness.

Wood pipe will always deliver the water with its natural purity unchanged. The inside of this pipe will always remain clean and free from rust, scale, and tuberculation.

It gives us great pleasure to present to you in this handbook some of the engineering principles involved in the design, manufacture, installation, and use of "National Quality" wood pipe.



Plant of the National Tank & Pipe Company, Kenton Station, Portland, Oregon

TECHNICAL SERVICE

For more than forty years our organization has been manufacturing wood tanks and wood pipe. During this long period of time we have accumulated, through practical experience and observation, a large store of information on tank and pipe problems. Let us assist you in the preparation of plans and specifications covering your requirements.

ORGANIZATION

This organization for more than 40 years has been engaged in meeting economically and effectively the needs of those whose business it is to regard water in terms of maximum usefulness.

With any man-fabricated product one must appraise not only the product but the facilities, the technical and manufacturing experience, and the integrity and financial soundness of the manufacturer.

An appraisal starts with the basic material—the wood from which the pipe is made. Douglas Fir has long been recognized as the wood of inherent strength and durability.

The natural habitat of Douglas Fir is the western part of Oregon and Washington, in the heart of which area strategically is located the National Tank & Pipe Company's plant.

Despite the obvious advantages of location, this company is highly discriminating in its insistence upon the use of only the best wood produced. Rigid specifications mark the first step in the manufacturing process.

The same scrupulous adherence to high standards follows the selected wood through the mill to the place where it starts a long life of usefulness. At every point the experience of many years of "knowing how" adds to its value. Research, design—how best to meet specific needs—these are part and parcel of "National Quality" Service.

Faithfulness to common-sense ideals has been reflected in soundness of financial structure, ability to insist upon high standards without compromise and to assure prospective customers of readiness to serve them not only today—but tomorrow.

WATER

Water is a means whereby human life is sustained, plants quickened and helped to grow, manufacturing industries made possible, and communities made livable and prosperous.

Various methods of giving utility to water through the use of wood stave pipe are described in this handbook. In presenting this data we have chosen to introduce the subject with a discussion on the fundamental principles involved in the design of various types of pipe lines. Because each particular project presents individual problems, this discussion and those which follow, necessarily are general ones. In working up preliminary or final plans and specifications, it will be our pleasure to assist you in every possible way.

Our Engineering Department is prepared to furnish helpful information on all technical phases of pipe line design.

PIPE LINE DESIGN

In simple terms, the design of a pipe line depends upon the quantity of water available or the amount needed for productive use or consumption, and the fall or pressure head between the intake and discharge. These factors determine the size of pipe to be used.

Wood pipe is manufactured not only to the required size but it is banded for the specific head under which it is to be operated. If, for example, one section of the line operates under a 50-foot head, another under a 100 foot head, and still another under a 300-foot head, the various sections are manufactured to meet these specific requirements. Obviously it is wasteful to specify an entire installation for 300-foot head when major portions of the line can be satisfactorily served by pipe banded for 50-foot head.

It is usually possible, moreover, to select a location for the pipe line where the major section of the line would be under a low head and only a small part of it subjected to higher pressures. This is good pipe line design and results in a great saving, as the cost of pipe varies with the pressure for which it is manufactured. On the other hand, a pipe line can be designed to operate under a high head throughout, resulting in a much higher cost and no better service.

Wood is hygroscopic—it absorbs water. When completely saturated, continually full, and under pressure, it withstands decay indefinitely. Hence, in designing untreated pipe lines, it is economically important that saturation pressure be reached as quickly as possible. This is accomplished by immediately dropping the line from the intake to a head of 25 feet or more.

If for any reason existing conditions make it impracticable to keep the line completely full and under pres-

sure at all times, as is the case where wood pipe is used for culverts, storm and sanitary sewers, and irrigation systems, it is advisable to have the pipe staves pressure treated with creosote or some other comparable preservative.

It is frequently found advantageous to specify pressure treated pipe for the upper end of a line where the head is low and untreated pipe for the lower end where the water pressure insures complete saturation of the staves.

Types of Wood Pipe: Wood pipe is made in two general types: machine banded and continuous stave.

Machine banded wood pipe is manufactured in random lengths up to 20 feet. Each joint complete with its coupling is a finished piece of pipe ready for installation. This type of pipe is spirally wrapped with heavily galvanized steel wire in a machine especially designed for this purpose.

Continuous stave pipe is manufactured complete and shipped to the site of erection knocked down. This type of pipe is erected on the job and is banded with individual round steel bands.

Range of Sizes: Machine banded pipe is made in sizes from 2 inches to 24 inches inside diameter.

Continuous stave pipe is made in sizes from 6 inches to 20 feet inside diameter. This type is used principally for sizes larger than 24 inches diameter; however, the smaller sizes have a distinct application in industrial installations or where transportation facilities are such that a saving in cost can be made by shipping the pipe in knocked down form.

Range of Heads: Wood pipe is always specified by the head under which it is to be operated. For example,

150-foot head pipe is manufactured for a maximum head of 150 feet or an internal pressure of its equivalent, 65.03 pounds per square inch.

Machine banded pipe is manufactured for various heads from 50 to 400 feet, varying by 50-foot intervals of head. Continuous stave pipe is banded for intervals of 10-foot head. Smaller sizes of continuous stave pipe are banded for heads up to 400 feet while the maximum heads for very large pipe are somewhat lower.

Head or Pressure: In specifying pipe it has become common practice to use the term "head" instead of "internal pressure." The head at any point in the pipe line is the height of the hydraulic grade line above that point. This simply means that if an open vertical tube were connected to the pipe line at the point under consideration, the water in the tube would rise to a height equal to the head, which is the distance of the hydraulic grade line above that point. For example, a 150-foot head pipe will withstand the internal pressure exerted by a vertical column of water 150 feet high. This in terms of internal pressure would be equal to 65.03 pounds per square inch. Thus it will be seen that the terms "head" and "internal pressure" are not synonymous and that it is much simpler to specify pipe in terms of head than in pounds per square inch.

On the following pages will be found a table giving the pressure in pounds per square inch equivalent to a given head.

Pressure of Water

Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch
1	0.43	51	22.11	101	43.78
2	0.87	52	22.54	102	44.22
3	1.30	53	22.98	103	44.65
4	1.73	54	23.41	104	45.08
5	2.17	55	23.84	105	45.52
6	2.60	56	24.28	106	45.95
7	3.03	57	24.71	107	46.38
8	3.47	58	25.14	108	46.82
9	3.90	59	25.58	109	47.25
10	4.34	60	26.01	110	47.69
11	4.77	61	26.44	111	48.12
12	5.20	62	26.88	112	48.55
13	5.64	63	27.31	113	48.99
14	6.07	64	27.74	114	49.42
15	6.50	65	28.18	115	49.85
16	6.94	66	28.61	116	50.29
17	7.37	67	29.04	117	50.72
18	7.80	68	29.48	118	51.15
19	8.24	69	29.91	119	51.59
20	8.67	70	30.35	120	52.02
21	9.10	71	30.78	121	52.45
22	9.54	72	31.21	122	52.89
23	9.97	73	31.65	123	53.32
24	10.40	74	32.08	124	53.75
25	10.84	75	32.51	125	54.19
26	11.27	76	32.95	126	54.62
27	11.70	77	33.38	127	55.05
28	12.14	78	33.81	128	55.49
29	12.57	79	34.25	129	55.92
30	13.01	80	34.68	130	56.36
31	13.44	81	35.11	131	56.79
32	13.87	82	35.55	132	57.22
33	14.31	83	35.98	133	57.66
34	14.74	84	36.41	134	58.09
35	15.17	85	36.85	135	58.52
36	15.61	86	37.28	136	58.96
37	16.04	87	37.71	137	59.39
38	16.47	88	38.15	138	59.82
39	16.91	89	38.58	139	60.26
40	17.34	90	39.02	140	60.69
41	17.77	91	39.45	141	61.12
42	18.21	92	39.88	142	61.56
43	18.64	93	40.32	143	61.99
44	19.07	94	40.75	144	62.42
45	19.51	95	41.18	145	62.86
46	19.94	96	41.62	146	63.29
47	20.37	97	42.05	147	63.72
48	20.81	98	42.48	148	64.16
49	21.24	99	42.92	149	64.59
50	21.68	100	43.35	150	65.03

Pressure of Water—Continued

Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch
151	65.46	211	91.47	271	117.48
152	65.89	212	91.90	272	117.91
153	66.33	213	92.34	273	118.35
154	66.76	214	92.77	274	118.78
155	67.19	215	93.20	275	119.21
156	67.63	216	93.64	276	119.65
157	68.06	217	94.07	277	120.08
158	68.49	218	94.50	278	120.51
159	68.93	219	94.94	279	120.95
160	69.36	220	95.37	280	121.38
161	69.79	221	95.80	281	121.81
162	70.23	222	96.24	282	122.25
163	70.66	223	96.67	283	122.68
164	71.09	224	97.10	284	123.11
165	71.53	225	97.54	285	123.55
166	71.96	226	97.97	286	123.98
167	72.39	227	98.40	287	124.41
168	72.83	228	98.84	288	124.85
169	73.26	229	99.27	289	125.28
170	73.70	230	99.71	290	125.72
171	74.13	231	100.14	291	126.15
172	74.56	232	100.57	292	126.58
173	75.00	233	101.01	293	127.02
174	75.43	234	101.44	294	127.45
175	75.86	235	101.87	295	127.88
176	76.30	236	102.31	296	128.31
177	76.73	237	102.74	297	128.75
178	77.16	238	103.17	298	129.18
179	77.60	239	103.61	299	129.62
180	78.03	240	104.04	300	130.05
181	78.46	241	104.47	305	132.22
182	78.90	242	104.91	310	134.39
183	79.33	243	105.34	315	136.55
184	79.76	244	105.77	320	138.72
185	80.20	245	106.21	325	140.89
186	80.63	246	106.64	330	143.06
187	81.06	247	107.07	335	145.22
188	81.50	248	107.51	340	147.39
189	81.93	249	107.94	345	149.56
190	82.37	250	108.38	350	151.73
191	82.80	251	108.81	355	153.89
192	83.23	252	109.24	360	156.06
193	83.67	253	109.68	365	158.23
194	84.10	254	110.11	370	160.40
195	84.53	255	110.54	375	162.56
196	84.97	256	110.98	380	164.73
197	85.40	257	111.41	385	166.90
198	85.83	258	111.84	390	169.07
199	86.27	259	112.28	395	171.23
200	86.70	260	112.71	400	173.40
201	87.13	261	113.14	410	177.74
202	87.57	262	113.58	420	182.07
203	88.00	263	114.01	430	186.41
204	88.43	264	114.44	440	190.74
205	88.87	265	114.88	450	195.08
206	89.30	266	115.31	460	199.41
207	89.73	267	115.74	470	203.75
208	90.17	268	116.18	480	208.08
209	90.60	269	116.61	490	212.42
210	91.04	270	117.05	500	216.75

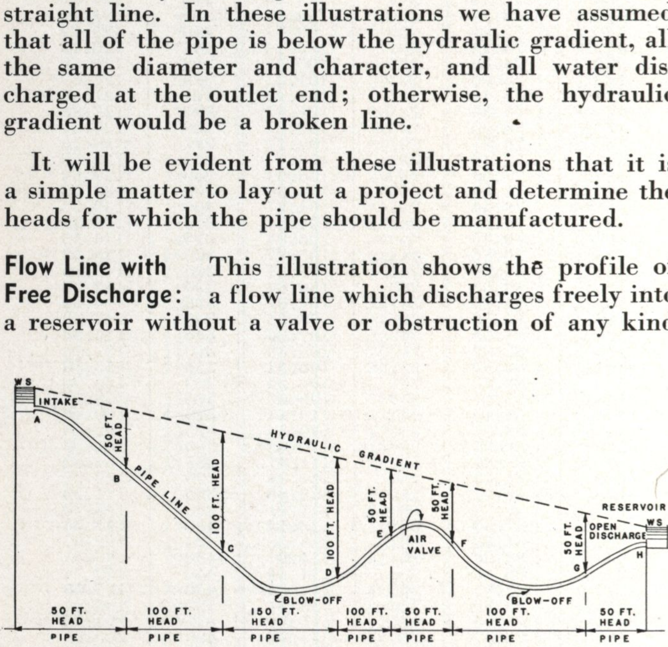
Determination of Head: It is not a difficult matter to determine the head under which each part of a pipe line is to be operated; however, on major projects this work should be entrusted to a qualified engineer who is familiar with all phases of the problem.

The head is always equal to the vertical distance from the center of the pipe to the hydraulic gradient. The position of the hydraulic gradient depends upon whether the project is a flow line with free discharge, a flow line with restricted discharge, or a pumping line.

We shall illustrate three typical pipe line designs in which the hydraulic gradient can be considered as a straight line. In these illustrations we have assumed that all of the pipe is below the hydraulic gradient, all the same diameter and character, and all water discharged at the outlet end; otherwise, the hydraulic gradient would be a broken line.

It will be evident from these illustrations that it is a simple matter to lay out a project and determine the heads for which the pipe should be manufactured.

Flow Line with Free Discharge: This illustration shows the profile of a flow line which discharges freely into a reservoir without a valve or obstruction of any kind



at the outlet. It will be observed that the hydraulic gradient is a straight line connecting the water surface at the intake with the water surface at the discharge and that the head is the vertical distance between the center of the pipe and the hydraulic gradient.

In specifying pipe for this design, the section of pipe from A to B would be a 50-foot head; from B to C, 100-foot head; from C to D, 150-foot head; then, as the pipe line again approaches the hydraulic gradient, the head is lower and from D to E the 100-foot head pipe can again be used. In laying out a project in this manner a great saving can be made since the lower the head, the less expensive the pipe.

It is very good pipe line design to use a free discharge wherever possible, as the use of a valve at the discharge end of a pipe raises the hydraulic gradient and consequently increases the head on the pipe, as will be shown in the following example.

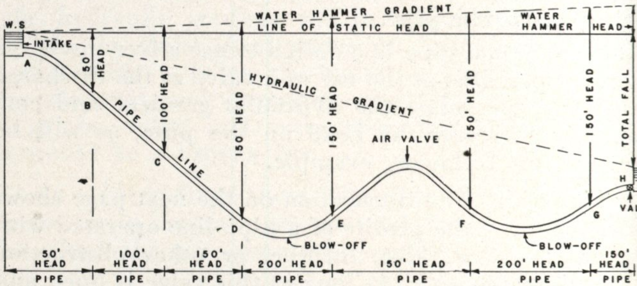
Flow Line with Restricted Discharge: The illustration on the next page shows the profile of a pipe line operated with a valve, turbine, or other obstruction at the discharge end. As long as this valve is open and the water allowed to flow freely into space, the hydraulic gradient can be considered as a straight line connecting the water surface at the intake with the center of the pipe at the discharge. When the valve is closed slowly, the hydraulic gradient gradually approaches and finally coincides with the line of static head. When the valve is closed rapidly, a surge or water hammer develops in the pipe line, causing an additional pressure which raises the hydraulic gradient above the line of static head. The amount of this increase is dependent upon the rapidity with which the valve is closed.

This increased head should be anticipated in the design of the pipe line. It is not as great in wood pipe as in pipe lines made of rigid material. Due to its

elasticity, wood pipe absorbs a considerable portion of this excess pressure.

In determining the head under this condition, due allowance should be made for water hammer, and the hydraulic gradient drawn from the water surface at the intake to a point directly over the discharge. The elevation of this point above the discharge is equal to the difference in elevation between the water surface at the intake and the center of the pipe at the discharge end, plus the extra head developed by water hammer.

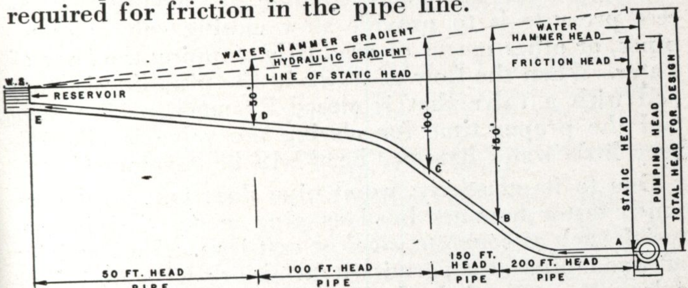
See tables and formula pages 16 and 17.



The head on this pipe line is the vertical distance from the center of the pipe line to the hydraulic gradient when moved to the position of the water hammer gradient as shown in the illustration.

This excess pressure due to water hammer is instantaneous; however, the pipe must be designed to withstand it. Consequently, in the specification of the pipe for this design, 50-foot head pipe would be used from A to B, 100-foot head from B to C, 150-foot head from C to D, and 200-foot head from D to E. It will be noted that these heads are considerably higher than those in the preceding example where the heads were measured from the hydraulic gradient connecting the two water surfaces.

Pumping Line: The illustration shows a profile of a pumping line in which the water is pumped uphill and discharged into a reservoir. When the pump is operating, the hydraulic gradient can be considered as a straight line connecting the water surface at the reservoir with a point directly above the pump. The elevation of this point is equal to the static head plus the head required for friction in the pipe line.



When the pump is shut down, water hammer head will be developed. If equipment is provided to reduce the water hammer head so that it does not exceed the head allowed for friction in the pipe line, the water hammer gradient will coincide with or be below the hydraulic gradient; in which case, the head on the pipe must be measured from the hydraulic gradient down to the center of the pipe. If equipment is not provided to reduce the water hammer head to equal or be less than the friction head, the water hammer gradient will be above the hydraulic gradient and the head on the pipe must be measured from this water hammer gradient down to the center of the pipe.

The water hammer gradient can be drawn as a straight line connecting the water surface of the reservoir at the discharge with a point directly above the pump. The elevation of this point would be equal to the static head plus the water hammer head (See pages 16 and 17). In any event, the head on the pipe should be measured from the water hammer gradient or the hydraulic gradient, whichever is the greater.

Water Hammer Head: Water hammer head is the excess pressure developed in the pipe line due to sudden change in the velocity of the water flowing through the pipe. The amount of this pressure varies with the rapidity with which the velocity is changed.

The best safeguard for any pipe line against this excess pressure is to provide slow closing valves, standpipes, or other means of gradually stopping the flow of water. When the flow of water in the pipe line is stopped with a valve that is closed by mechanical means and the proper time for closing the valve is allowed, very little water hammer head will be developed.

Due to its elasticity, wood pipe does not develop as much water hammer head as pipe made of rigid material, such as concrete, steel or cast iron. The elasticity of wood pipe also permits it to absorb without injury a large amount of the head which is developed.

As yet no exact formula has been derived for determining the actual amount of water hammer head developed in wood stave pipe lines; however, from practical experience we have derived the following formula which is not intended to give the theoretical amount of water hammer head developed but does give the amount that we consider adequate for wood pipe design.

$$h = V^{1.5} + 2L + \frac{2d + H}{14}$$

in which: h = water hammer head for design
V = velocity of water in pipe
L = length of pipe in thousands of feet
d = inside diameter of pipe in inches
H = static head

The amount of water hammer head, "h," derived from this formula should be added to the static head in the design of all wood stave pipe lines having any form of restricted discharge, where water hammer is anticipated.

For your convenience in arriving at the amount of

excess head due to water hammer, the following tables have been prepared. There are two tables, one giving the value of "h" for a pipe having a given length and velocity, and one giving the value of "h" for a pipe having a given diameter and static head. The values in the two tables must be added together to get the excess head to be added to the static head for design purposes.

WATER HAMMER HEAD TABLES

These tables give values of "h" which were obtained from practical experience and are for the design of wood stave pipe lines only.

Values of $h = V^{1.5} + 2L$

Velocity in Feet per Second	Length of Pipe in Feet								
	1000	2000	3000	4000	5000	6000	8000	10000	15000
1	2	4	6	8	10	12	16	20	30
2	5	7	9	11	13	15	19	23	33
3	7	9	11	13	15	17	21	25	35
4	10	12	14	16	18	20	24	28	38
5	13	15	17	19	21	23	27	31	41
6	17	19	21	23	25	27	31	35	45
7	21	23	25	27	29	31	35	39	49
8	25	27	29	31	33	35	39	43	53
9	29	31	33	35	37	39	43	47	57
10	34	36	38	40	42	44	48	52	62

Values of $h = \frac{2d + H}{14}$

Static Head in Feet	Diameter of Pipe in Inches								
	6	12	24	36	48	60	72	84	96
50	4	5	7	9	10	12	14	16	17
100	8	9	11	12	14	16	17	19	21
150	12	12	14	16	18	19	21	23	24
200	15	16	18	19	21	23	25	26	28
250	19	20	21	23	25	26	28	30	32
300	22	23	25	27	28	30	32	33	35

Add values given in both tables to find water hammer head for use in the design of wood stave pipe. We consider this amount of excess head adequate for the design of wood stave pipe lines that are to be operated under normal conditions. In some cases field and operating conditions may warrant a further study of this problem.

Relative Capacities: Those who wish to compare the relative carrying capacities of various sizes of pipes, for estimating purposes, will find the following table a great convenience. It is self-explanatory.

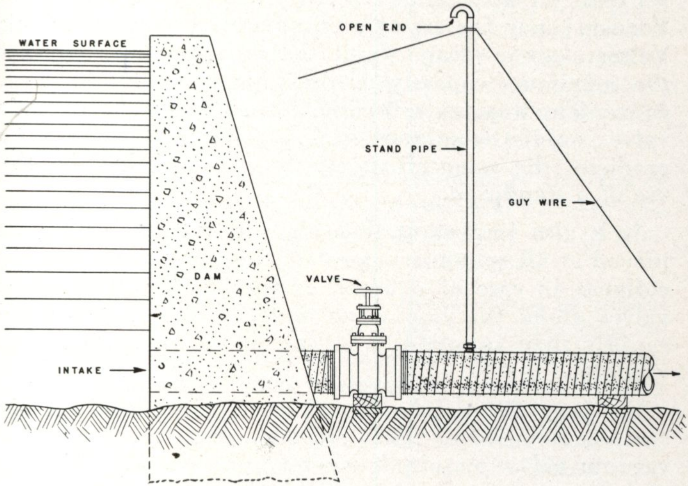
Relative Capacity of Pipes of Different Diameters

This table is based on discharge of pipes having a friction head of one foot in one thousand feet as given in the Flow Tables in this book.

For Preliminary Use Only

Dia in ins.	2″	3″	4″	5″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″
2″	1.0	....	....	....	....	....	....	....	....	....	....	....	....	....
3″	2.9	1.0	....	....	....	....	....	....	....	....	....	....	....	....
4″	6.3	2.1	1.0	....	....	....	....	....	....	....	....	....	....	....
5″	11.0	3.9	1.8	1.0	....	....	....	....	....	....	....	....	....	....
6″	18.0	6.3	2.9	1.6	1.0	....	....	....	....	....	....	....	....	....
8″	40.0	14.0	6.3	3.5	2.2	1.0	....	....	....	....	....	....	....	....
10″	....	25.0	11.0	6.3	3.9	1.8	1.0	....	....	....	....	....	....	....
12″	....	40.0	18.0	10.0	6.3	2.9	1.6	1.0	....	....	....	....	....	....
14″	....	....	28.0	15.0	9.5	4.4	2.5	1.5	1.0	....	....	....	....	....
16″	....	....	40.0	22.0	14.0	6.3	3.5	2.2	1.4	1.0	....	....	....	....
18″	....	....	....	30.0	19.0	8.6	4.8	3.0	2.0	1.4	1.0	....	....	....
20″	....	....	....	40.0	24.0	11.0	6.3	3.9	2.6	1.9	1.4	1.0	....	....
22″	....	....	....	....	31.0	15.0	8.1	5.0	3.3	2.4	1.7	1.3	1.0	....
24″	....	....	....	....	40.0	19.0	10.0	6.3	4.2	3.0	2.2	1.6	1.3	1.0
26″	....	....	....	....	49.0	23.0	13.0	7.8	5.2	3.7	2.7	2.0	1.6	1.3
28″	....	....	....	....	....	28.0	16.0	9.5	6.3	4.4	3.2	2.5	1.9	1.5
30″	....	....	....	....	....	33.0	19.0	11.0	7.5	5.3	3.9	3.0	2.3	1.8
32″	....	....	....	....	....	40.0	22.0	14.0	8.9	6.3	4.6	3.5	2.7	2.2
34″	....	....	....	....	....	46.0	26.0	16.0	11.0	7.4	5.4	4.1	3.2	2.6
36″	....	....	....	....	....	54.0	30.0	19.0	12.0	8.6	6.3	4.8	3.7	3.0
38″	....	....	....	....	....	....	35.0	22.0	14.0	10.0	7.2	5.5	4.3	3.4
40″	....	....	....	....	....	....	40.0	25.0	16.0	11.0	8.3	6.3	4.9	3.9
42″	....	....	....	....	....	....	45.0	28.0	18.0	13.0	9.5	7.2	5.6	4.4
44″	....	....	....	....	....	....	51.0	31.0	21.0	15.0	11.0	8.1	6.3	5.0
46″	....	....	....	....	....	....	....	36.0	24.0	17.0	12.0	9.1	7.1	5.7
48″	....	....	....	....	....	....	....	40.0	26.0	19.0	14.0	10.0	8.0	6.3

To illustrate this table, it will be seen that the discharge from one 10-inch pipe is equivalent to the discharge from eleven 4-inch pipes.



Standpipes: To prevent the formation of a vacuum, standpipes are placed on the discharge side of the valve at the intake of a pipe line. They vary with the size of the pipe. On small pipe lines they may consist of a piece of small galvanized iron pipe connected to the line with a brass tapping nipple. The standpipe should extend slightly above the top of the dam. On large pipe lines the standpipe can be economically made with a piece of creosoted Douglas Fir pipe connected to the main with a saddle.

Surge Tanks: In the design of pipe lines for power plants it is often found necessary to install a surge tank to act as regulator for the purpose of controlling the flow of water to the turbines and to relieve excess pressure due to variation in the load carried by the plant. We shall be pleased to assist in the design of standpipes or surge tanks to meet particular requirements.

Air and Vacuum Valves: At all summits in pipe lines there is a tendency for air to accumulate. A means for this air to escape should be provided in order that the maximum capacity of the pipe be maintained. A convenient way for releasing this air is through an air valve; or, if the summit is very close to the hydraulic gradient, the same effect can be accomplished by the use of a standpipe.

It is also important that air and vacuum valves be placed at all summits to protect the pipe from possible collapse in case of a break or the sudden opening of valves along the line when water is drawn off more rapidly than supplied, resulting in the formation of a vacuum.

On page 79 will be found a description of an air and vacuum valve. The size and quantity of air and vacuum valves required depend upon the size of pipe and the conditions under which it is operated. We shall be pleased to assist in solving problems of this kind.

Preliminary Design: The first step in developing any pipe line project is to make a preliminary survey for the purpose of determining whether or not the project is feasible and economically practical. The procedure varies with the type of project under consideration. Of first importance is the necessity of making a rough estimate of the amount of water available and an appraisal of the field conditions under which the line is to be laid.

Several basic factors must be weighed; among them, the selection of the most economical type of pipe for the particular purpose, the cost of right-of-way, and field problems presented by various proposed locations. Not infrequently, on many installations, the accessibility of the location and readiness with which materials can be brought to the site of erection are controlling factors which dictate the selection of wood pipe.

Wood pipe is light and easy to haul and distribute along the pipe line grade. In large sizes wood pipe is shipped knocked down and can be easily transported to the site of erection even under most adverse conditions, while large sizes of pipe made of other materials would involve great hauling and distributing expense.

In order to make even a rough estimate of the cost of conveying water from its source to the final place of use, alternate routes should be surveyed and the cost of various sizes of pipe for each route determined.

Our organization has been in the business of manufacturing and installing wood pipe for more than 40 years. During this period we have accumulated, through practical experience and observation, a wealth of very valuable information on pipe problems which is available through our engineering department. Estimates will be furnished for any type of project, whether it be large or small.

When requesting information or prices on pipe line projects it will expedite matters if we are furnished a rough profile and an alignment drawing of the proposed line together with information on transportation facilities and all other data that may be helpful. The clearer the picture of the problem, the more complete will be our treatment of it.

Given the necessary information our engineering department will be able to determine the proper size of pipe; whether it would be more economical to use machine banded or continuous stave pipe; whether certain portions of the line should be treated or untreated; and whether a semi-circular flume would have better application than a pipe line.

On the following pages we have set forth suggested information forms as a guide for those who desire prices on wood pipe.

INFORMATION REQUIRED WITH INQUIRIES FOR PRICES

MACHINE BANDED PIPE

Sizes: 2 inches to 24 inches, inside diameter.

1. State the size of pipe and the length required under each head as shown below:

	Size..........	Size..........	Size..........
HEAD	Length	Length	Length
50 Ft.	Ft.	Ft.	Ft.
100 Ft.	Ft.	Ft.	Ft.
150 Ft.	Ft.	Ft.	Ft.
200 Ft.	Ft.	Ft.	Ft.
250 Ft.	Ft.	Ft.	Ft.
300 Ft.	Ft.	Ft.	Ft.
350 Ft.	Ft.	Ft.	Ft.
400 Ft.	Ft.	Ft.	Ft.

2. The quantity of water to be delivered through each size ....

3. Will the project be a gravity or pumping system?

....

4. If possible, send plans and profiles, or sketch, showing pipe location, elevation at intake, discharge points, etc.

5. When do you plan the commencement and completion of the installation?

Note: *Do not tear this page from book—just use it as a guide.*

INFORMATION REQUIRED WITH INQUIRIES FOR PRICES

CONTINUOUS WOOD STAVE PIPE

Sizes: 6 inches to 20 feet, inside diameter.

1. State the size of pipe and the length in feet required under each head as shown below:

Size of Pipe..............................

Head	Quantity	Head	Quantity	Head	Quantity
10		110		210	
20		120		220	
30		130		230	
40		140		240	
50		150		250	
60		160		260	
70		170		270	
80		180		280	
90		190		290	
100		200		300	

2. The quantity of water to be delivered..........................

3. Will the project be a gravity or pumping system?

....

4. If possible, send plans and profiles, or sketch, showing pipe location, elevation at intake, discharge points, etc.

5. When do you plan the commencement and completion of installation?

Note: *Do not tear this page from book—just use it as a guide.*

Blow-offs: Blow-off valves or clean-outs should be installed at all low points in the pipe line to remove deposits of rocks, silt and other materials which may accumulate in the line, and to make possible the draining of low sections between summits when desired.

Anchors: All pipe lines erected on steep slopes should be anchored to prevent downward movement. This can be accomplished on short slopes by placing a secure anchor at the bottom. On long slopes it is sometimes advisable to place anchors along the line as well as at the bottom. The usual way of constructing an anchor is to place a heavy concrete pier beneath the pipe and anchor the pipe line to it by means of heavy steel straps extending over it. The design of these anchors is entirely dependent upon field conditions.

Expansion Joints: There is neither longitudinal expansion nor contraction in wood pipe; therefore, expansion joints can be completely eliminated from the design. This is true of wood pipe regardless of the climatic conditions under which it is used and whether it is laid above or below ground. On metal pipe lines it is necessary to use expansion joints, the number of which depends upon climatic and field conditions. The cost of these expansion joints is of major importance in pipe line design.

Installation: The hauling, distribution, and installation of wood pipe can be accomplished for less money than would be required for any other type of pipe. The erection of wood pipe is not a difficult job; however, it can be done faster and better by men who are experienced in this line of work. On large projects we are prepared to contract for the pipe lines erected, complete, ready for use. On small projects it is usually more economical to install the pipe with local labor. When desired we can furnish one of our construction superintendents to supervise the work of local labor.

Loss of Head in Bends: Wood pipe can be built to the natural curvature of the ground without the use of special fittings. The finished curves are not only pleasing in appearance but very efficient, there being no sharp angles to cause friction loss.

Where it is necessary to use steel or cast iron bends in pipe lines a certain amount of head is lost depending upon the degree of bend and the velocity of the water in the line. The following table will be found valuable in ascertaining this loss.

Loss of Head — Bends

Table Showing Loss of Head Due to the Resistance of One Angular Bend

Velocity in Feet per Second	ANGLES OF DEFLECTION					
	15° Friction Head	30° Friction Head	40° Friction Head	60° Friction Head	90° Friction Head	120° Friction Head
1	.0002	.0005	.002	.006	.015	.029
2	.0010	.0019	.009	.023	.061	.116
3	.0022	.0042	.019	.051	.138	.260
4	.004	.008	.035	.090	.245	.462
5	.006	.012	.054	.141	.382	.723
6	.009	.017	.078	.204	.550	1.04
7	.012	.023	.106	.277	.749	1.42
8	.016	.030	.138	.362	.978	1.85
10	.025	.047	.216	.565	1.53	2.89
15	.056	.105	.486	1.27	3.44	6.50

Efficiency: Wood pipe will deliver water year after year for less money than any other kind of pipe. It will not corrode or pit. The staves remain clean after years of use and there is no scale, rust or tuberculation. Because of its smooth interior surface which remains smooth throughout its service life it is unquestionably the most efficient type of pipe made.

THE ECONOMICS OF WOOD PIPE

In the final analysis, the purchase of any kind of pipe embraces not only technical factors of design and installation but the question of financing. The use of credit for this purpose creates a definite carrying charge against the project in the form of interest. In many instances interest charges in the aggregate exceed the original cost of the development.

Taxpayers and stockholders now are more closely scrutinizing projects in terms of (1) carrying charges; and (2) whether the communities and corporations have or can get the funds to complete them—and repay the loans.

If, as is the case, there is a wide difference in cost between various types of pipe, another aspect should be considered. For example, assuming costs prevailing at the time this handbook was prepared, a given installation would cost $50,000 if wood pipe were used, and over $100,000 if cast iron pipe of equal capacity were specified. It will be obvious that the interest on the saving of $50,000 at 6% would renew the wood pipe every 12 years, if that were necessary.

Even if the difference in cost were not so pronounced, the interest factor plays a controlling part and may dictate the selection of the less expensive pipe for financial reasons alone.

The cost of money, therefore, is one of the prime reasons wood pipe increasingly is being specified.

Amortization Table

Percentage of Saving on Purchase Price	Number of Years Required for Saving to Return the Original Cost		
	At 6 % Interest	At 5 % Interest	At 4 % Interest
60 % will require	9 years	10 years	13 years
59 % " "	9 "	11 "	13 "
58 % " "	9 "	11 "	14 "
57 % " "	10 "	11 "	14 "
56 % " "	10 "	12 "	15 "
55 % " "	10 "	12 "	15 "
54 % " "	11 "	13 "	16 "
53 % " "	11 "	13 "	16 "
52 % " "	11 "	13 "	17 "
51 % " "	12 "	14 "	17 "
50 % " "	12 "	14 "	18 "
49 % " "	12 "	15 "	18 "
48 % " "	13 "	15 "	19 "
47 % " "	13 "	16 "	19 "
46 % " "	13 "	16 "	20 "
45 % " "	14 "	16 "	20 "
44 % " "	14 "	17 "	21 "
43 % " "	15 "	17 "	22 "
42 % " "	15 "	18 "	22 "
41 % " "	15 "	18 "	23 "
40 % " "	16 "	19 "	23 "
39 % " "	16 "	19 "	24 "
38 % " "	17 "	20 "	25 "
37 % " "	17 "	20 "	25 "
36 % " "	18 "	21 "	26 "
35 % " "	18 "	22 "	27 "
34 % " "	19 "	22 "	28 "
33 % " "	19 "	23 "	28 "
32 % " "	19 "	23 "	29 "
31 % " "	20 "	24 "	30 "
30 % " "	21 "	25 "	31 "

With this table it is possible to calculate the number of years required for an initial saving to return the original cost. For example: A saving of 50% at 6% interest will return the original cost in 12 years.

"National Quality" wood stave pipe will deliver water year after year cheaper than pipe made of any other material.

DOUGLAS FIR

(*Pseudotsuga Taxifolia*)

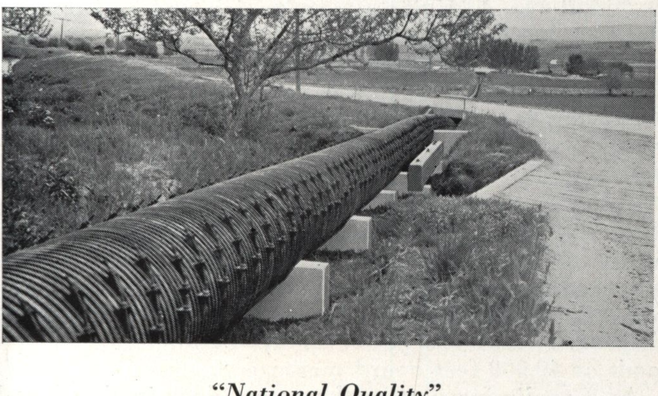
Douglas Fir, the Botanist tells us, is neither a fir nor a spruce but a particular tree species grown only in the

western parts of Oregon and Washington. Douglas Fir is scientifically known as *Pseudotsuga Taxifolia.*

So-called Douglas Fir growing in localities other than the Pacific Northwest does not possess as great strength and is not in other respects equal in quality. East of the Cascade Range and south of central Oregon, the trees are smaller in diameter and inferior in strength and those other qualities which make the best class of pipe staves.

Surveys made by the United States Forest Service indicate that 25% of the standing timber in the continental United States is concentrated in the west coast region of Oregon and Washington.

From Douglas Fir is produced more lumber than from any other tree species of the world. It has a greater variety of uses than any other wood known and is one of the strongest woods for its weight that has ever been tested. It is durable, and its many outstanding qualities make it especially adaptable for use in the production of wood pipe and wood tanks.



"National Quality"
48" diameter Continuous Stave Pipe

PRESERVATIVE TREATMENT

Wood pipe that is kept full and under pressure will remain in excellent condition for an indefinite period because wood does not deteriorate when its cells are saturated with water. Abundant historical data substantiate this statement.

When wood pipe is used for culverts, storm and sanitary sewers, low pressure irrigation systems that may not be completely and constantly filled, and those purposes requiring only intermittent use, the important prerequisite of water-saturated cells cannot be fulfilled. Under these conditions and also when the pipe is to be exposed to fungi, insects, or marine borers, it is desirable to fortify the wood with a preservative.

Impregnation under pressure is the only satisfactory means of injecting preservatives into wood. The practice of pressure treating has been in use for over a century.

THE CREOSOTE PROCESS AS APPLIED TO WOOD PIPE STAVES

For reasons that later will appear, creosote is most commonly used. Uniform penetration and a clean, dry finished product are characteristics of the improved process now being used. When protected in this way the operating life of wood pipe even under adverse conditions is conservatively estimated in excess of fifty years.

The Pressure Process: The method of treating Douglas Fir pipe staves is as follows: On arrival at the creosoting plant the thoroughly kiln-dried staves, which have been milled to pattern, are loaded on tram cars and drawn into huge cylindrical tanks known as retorts. These retorts are about 135 feet long and 7 feet in diameter; they each have a capacity of approximately two carloads or 40,000 feet board measure.

As a preliminary step, the retort door is closed and creosote oil pumped into the retort. The temperature

of the oil is then raised gradually from about 170 degrees F. to not more than 190 degrees F. and a vacuum of about 25 inches is drawn to lower the boiling point. This operation requires about three hours. There is partial and spontaneous absorption during this period but the main purpose of the operation is to warm the staves in preparation for the treatment which follows.

The creosote is then drained from the retort and an air pressure of about 25 pounds per square inch is maintained for one hour.* This is done in order to compress the confined air in the wood cells. Without releasing or lowering this air pressure the creosote is pumped back into the retort and oil pressure applied until the required penetration and resulting absorption of the wood with creosote is accomplished. The oil pressure is then released.

As the air confined in the wood expands, the surplus creosote in the wood cells is forced out, leaving only the fibres impregnated with the preservative. The oil temperature is then speedily raised for a short period and the staves subjected to what is called an expansion bath. A final vacuum assists in driving off excess creosote and leaves the staves free from surface oil. The retort is drained and the charge withdrawn. A total time of approximately 12 hours is required for the complete treating cycle.

To determine the absorption, the staves are weighed before and after treatment. The amount injected ranges from 8 pounds to 12 pounds of creosote oil per cubic foot of wood, depending upon the proposed use of the pipe. For water pipe to be used under ordinary conditions the average net retention is 8 pounds.

Advantages of Coal Tar Creosote: The chief advantages of coal tar creosote as a wood preservative are: (a) its marked toxicity to wood destroying fungi,

*If the staves are to be exposed to salt water where marine borers are present, the creosote is not drained from the retort after warming the staves, nor is air pressure applied.

marine borers, and insects; (b) its relative insolubility in water; (c) its low volatility, to which the oil owes its high degree of permanence under the most varied service conditions; (d) its ease of application; (e) its general availability and relatively low cost.

In the specifications of the American Wood Preservers Association‡ coal tar creosote is defined as follows:

"Creosote used in wood preserving is a distillate of coal tar produced by high temperature carbonization of bituminous coal; it consists principally of liquid and solid aromatic hydrocarbons and contains appreciable quantities of tar acids and tar bases; it is heavier than water and has a continuous boiling range of at least 125 degrees C., beginning at about 200 degrees C."

Coal tar creosote is not a single chemical substance. It is a mixture containing probably several hundred chemical compounds. The known constituents may be grouped into three principal classes; namely, the tar acids, the tar bases, and the hydrocarbons.

The tar acids, which are not true acids in the chemical sense, usually comprise less than 5 per cent of a normal creosote. They include various phenols, cresols, xylenols, and naphthols, all of which are toxic to wood destroying fungi. The tar bases include the pyridines, quinolines, and acridines, most of which are toxic. The hydrocarbons which form the major part of creosote include benzene, toluene, xylene, naphthalene, and fluorene.

Specifications for coal tar creosote stipulate that the creosote oil shall be a derivative of coal tar. They provide definite restrictions as to its specific gravity and distillation range, and carefully limit the amount of undesirable impurities it may contain.

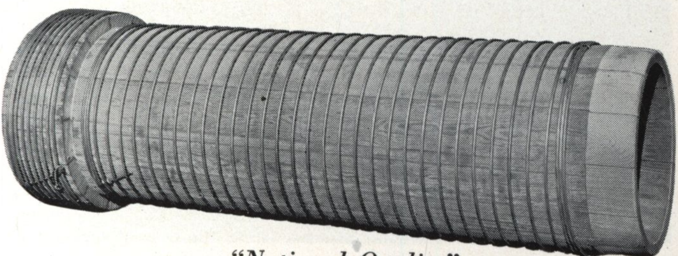
‡The specifications of this association are exactly the same as those adopted by the American Railway Association, the American Society for Testing Materials, the United States Government, and various industrial concerns.

WOLMANIZING PROCESS AS APPLIED TO WOOD PIPE STAVES

"Wolman Salts" preservative is dissolved in water for impregnation and the water removed by kiln-drying after treatment, leaving the protective salts diffused through the wood fibers. The vacuum-pressure, full-cell process is used in "Wolmanizing," in order to assure deepest possible penetration of the preservative solution. A preliminary high vacuum is employed to clear the wood cells of air or vapors and permit deep initial penetration. The succeeding pressure cycle is the same as in creosote impregnation.

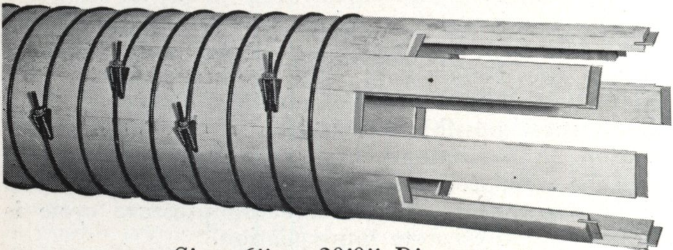
The preservative is entirely neutral in the presence of metals. It precipitates in insoluble form in the fibres of the wood, much like the setting of fast dyes in textile fibres.

"Wolman Salts" preservative is manufactured in two forms: "Tanalith," which contains a percentage of arsenate for specific protection against termites; and "Triolith," for use with food contacting applications of the treated lumber, which contains no arsenate. Where the use of material containing an arsenate is not desired, "Triolith" may be specified; therefore, "Tanalith" should be specified for industrial piping, culverts, sewers, etc., and "Triolith" should be specified where tanks or pipe are to be used for the storage or transportation of drinking water.



"National Quality"
Wolmanized Douglas Fir Pipe

CONTINUOUS STAVE WOOD PIPE

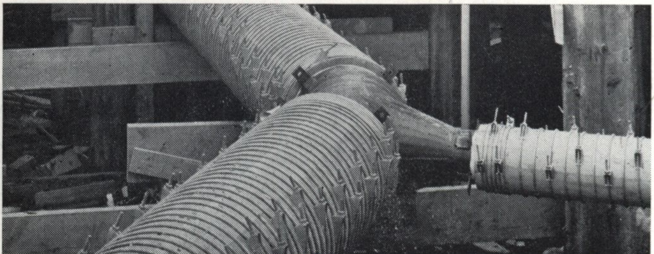


Sizes 6″ to 20′0″ Diameter

There are two types of "National Quality" wood pipe—continuous stave wood pipe as illustrated above and machine banded wood pipe illustrated on the opposite page.

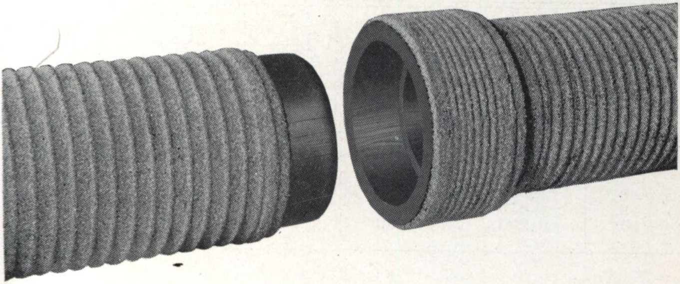
Continuous stave wood pipe is shipped knocked down, completely manufactured and ready to erect in the field. This pipe is fitted with individual steel bands connected with malleable iron pipe shoes. The joints connecting the staves end to end are made with either galvanized steel tongues or malleable iron butt joints.

"National Quality" continuous stave wood pipe is described in detail on pages 81 to 110.



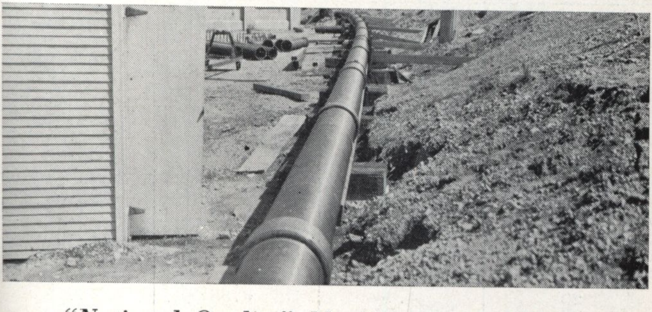
"National Quality" Continuous Stave Pipe

MACHINE BANDED WOOD PIPE



Sizes 2″ to 24″ Diameter

"National Quality" machine banded wood pipe is manufactured in random lengths up to 20 feet long. Each joint is a finished piece of pipe—ready to drive together—no joint materials or expensive equipment required. This type of wood pipe is fully described on the following pages.



"National Quality" Machine Banded Pipe

Approximate Freight Car Capacity

Machine Banded Pipe

BOX CAR

Inside Diameter of Pipe	Lineal Feet of Pipe in Standard 40 ft. Box Car	Lineal Feet of Pipe in Standard 50 ft. Box Car	Inside Diameter of Pipe	Lineal Feet of Pipe in Standard 40 ft. Box Car	Lineal Feet of Pipe in Standard 50 ft. Box Car
2″	12,000	19,250	12″	1,500	2,300
3″	9,350	14,150	14″	1,050	1,850
4″	7,350	12,000	16″	730	1,300
5″	5,600	9,600	18″	625	1,050
6″	4,300	7,200	20″	520	920
8″	2,550	4,650	22″	420	780
10″	1,900	3,300	24″	350	600

FLAT CAR

Inside Diameter of Pipe	Lineal Feet of Pipe on Standard 40 ft. Flat Car	Lineal Feet of Pipe on Standard 50 ft. Flat Car	Inside Diameter of Pipe	Lineal Feet of Pipe on Standard 40 ft. Flat Car	Lineal Feet of Pipe on Standard 50 ft. Flat Car
10″	2,880	3,600	18″	1,120	1,400
12″	2,240	2,800	20″	880	1,100
14″	1,600	2,000	22″	800	1,000
16″	1,360	1,700	24″	700	900

Cubic Measurement of "National Quality" Wood Pipe

Machine Banded Pipe — For Export by Steamer

One Cubic Ton = Forty Cubic Feet

Size Pipe Inches	Cubic Feet per Foot of Pipe	Lineal Feet of Pipe Per Ton	Cubic Tons Per 100 Feet of Pipe
2	0.14	286.0	0.35
3	0.23	174.0	0.58
4	0.33	121.0	0.83
5	0.44	91.0	1.10
6	0.62	64.5	1.55
8	0.87	46.0	2.17
10	1.22	32.8	3.05
12	1.67	24.0	4.17
14	2.15	18.6	5.38
16	2.75	14.6	6.88
18	3.36	11.9	8.41
20	4.06	9.86	10.15
22	4.80	8.33	12.00
24	5.57	7.18	13.93

Weights of "National Quality" Machine Banded Wood Stave Pipe

Diam. Inches	Head Feet	Weight per 100 Feet		Diam. Inches	Head Feet	Weight per 100 Feet	
		Untreated Coated	Creosoted Coated			Untreated Coated	Creosoted Coated
2	50	327	371	12	50	1680	1915
	100	337	381		100	1769	2004
	150	347	391		150	1935	2170
	200	362	406		200	2040	2275
	250	376	419		250	2155	2390
	300	383	427		300	2408	2643
	350	394	438		350	2581	2816
	400	407	451		400	2698	2933
3	50	426	481	14	50	1957	2228
	100	440	495		100	2097	2368
	150	455	510		150	2323	2594
	200	478	533		200	2464	2735
	250	497	552		250	2692	2963
	300	510	565		300	2960	3231
	350	527	582		350	3161	3432
	400	549	604		400	3431	3702
4	50	563	641	16	50	2404	2729
	100	579	657		100	2549	2874
	150	601	679		150	2780	3105
	200	623	701		200	2989	3314
	250	646	724		250	3354	3679
	300	672	750		300	3655	3980
	350	696	774		350	3811	4136
	400	728	806		400	4168	4493
5	50	668	762	18	50	2674	3037
	100	687	781		100	2880	3243
	150	719	813		150	3187	3550
	200	750	844		200	3429	3792
	250	774	868		250	3941	4304
	300	808	902		300	4193	4556
	350	839	933		350	4591	4954
	400	884	978		400	4872	5235
6	50	852	968	20	50	3059	3485
	100	870	986		100	3346	3772
	150	916	1032		150	3715	4141
	200	958	1074		200	4048	4474
	250	990	1106		250	4580	5006
	300	1033	1149		300	4948	5374
	350	1095	1211		350	5480	5906
	400	1156	1272		400	5834	6260
8	50	1081	1231	22	50	3360	3829
	100	1119	1269		100	3761	4230
	150	1176	1326		150	4213	4682
	200	1239	1389		200	4809	5278
	250	1305	1455		250	5217	5686
	300	1383	1533		300	5652	6121
	350	1458	1608		350	6082	6551
	400	1507	1657		400	6432	6901
10	50	1367	1551	24	50	3641	4153
	100	1430	1614		100	4144	4656
	150	1552	1736		150	4725	5237
	200	1585	1769		200	5357	5869
	250	1675	1859		250	5854	6366
	300	1907	2093		300	6437	6949
	350	1998	2182		350	6953	7465
	400	2124	2308		400	7435	7947

HOW MACHINE BANDED PIPE IS MADE

The Douglas Fir lumber is first thoroughly seasoned and then milled to the pipe stave pattern. The inside and outside faces of the staves are milled to the true concentric circles of the pipe, and the edges of the staves are milled to the true radial lines with a small groove on one edge and a corresponding tongue on the opposite edge.

The staves are assembled and clamped into position and then placed in a specially designed pipe-banding machine where, under uniform tension, they are wrapped with heavily galvanized steel wire manufactured especially for this purpose. Where chemical conditions warrant, the pipe can be banded with wire made of other metal or alloys to meet the requirements.

The machine banding operation is as follows: (1) the wire is stapled to one end of the pipe; (2) it is then bent back and three wraps laid tightly over it; (3) then the wire is spirally wrapped throughout the length of the pipe, the spacing and size of the wire depending upon the size of the pipe and the pressure under which it is to be operated; (4) three wraps are made in a specially designed clip at the other end of the pipe which holds the wire securely; (5) the wire, finally, is stapled at intervals of approximately 18 inches.

When this operation is completed, the pipe is taken to another machine where the ends are turned to fit the desired coupling or connection.

Finally, the outside of the pipe is heavily coated with hot coal tar and pitch to protect the wire; then it is rolled in fine sawdust as an added protection.

Each joint of pipe is fitted with its necessary couplings at the factory. When received at the job, it is ready for installation. All that is necessary is to drive it into position. The swelling of the wood makes the joint tight—no bolts, gaskets, or packing are necessary. Smooth inside and out, the pipe is ready for service.

TYPES OF MACHINE BANDED PIPE

Standard Pipe:

Untreated pipe with inserted joints
Untreated pipe with reinforced inserted joints
Untreated pipe with creosoted machine banded collars
Untreated pipe with creosoted individual banded collars
Untreated pipe with metal collars
Creosoted pipe with inserted joints
Creosoted pipe with reinforced inserted joints
Creosoted pipe with creosoted machine banded collars
Creosoted pipe with creosoted individual banded collars
Creosoted pipe with metal collars

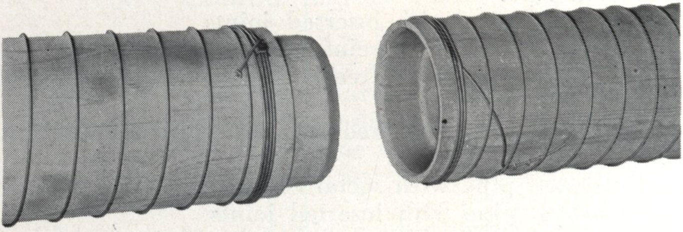
Special Pipe:

Creosoted irrigation pipe with steel collars
Creosoted sewer pipe and culverts
Untreated or creosoted industrial pipe designed especially to take care of particular requirements

"National Quality" machine banded pipe can be furnished with any type of coating or fabric covering required. When standard coating is specified, we dip the outside of the pipe in hot coal tar and pitch, and then roll it in fine sawdust.

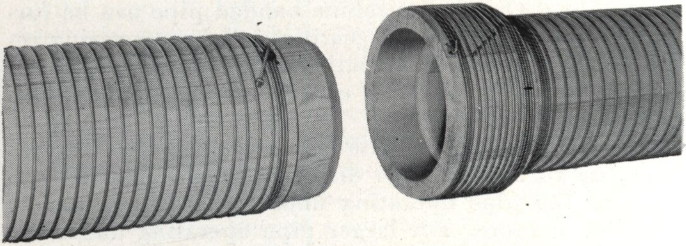
Machine banded collars are recommended for all pipe, up to 14 inches in diameter, in distribution systems or for pipe operating under a pressure head of 150 feet or more. For larger pipe operating under the same pressure, individual banded collars are used as it is impractical to make machine banded collars larger than 14 inches diameter.

The inserted joint type of coupling is recommended only for pipe operated under low heads; however, it can be used for higher heads on small pipe than on large pipe. Where inserted joint is used on pipe larger than 12 inches diameter, it is reinforced with steel bands. This is known as reinforced inserted joint.



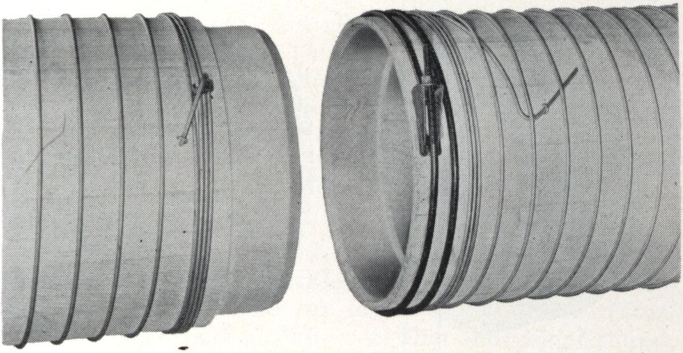
Inserted Joint

Inserted Joint: As will be made clear by the illustration, the inside of one end of the pipe is reamed out to form a mortise while the other end is shaped into a tenon. By simply driving the mortise of one pipe over the machine-turned tenon of the adjacent one, a perfect connection is made.



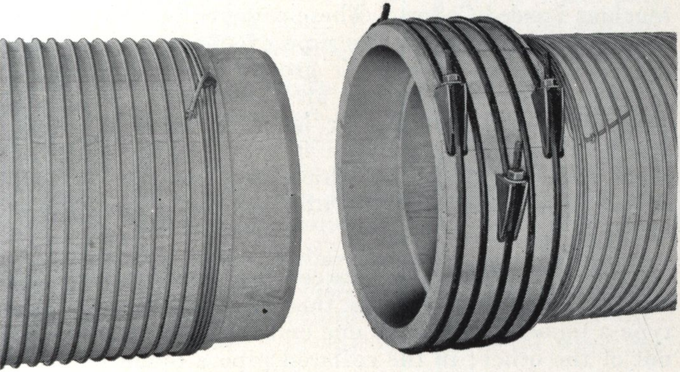
Machine Banded Collar

Machine Banded Collar: This type of collar is recommended for all pipe used in distribution systems and for any pipe used under heads of 150 feet or more. These collars are banded the same as the pipe except that the wire is spaced to give 50% greater strength. They are milled to make a perfect fit over the tenons.



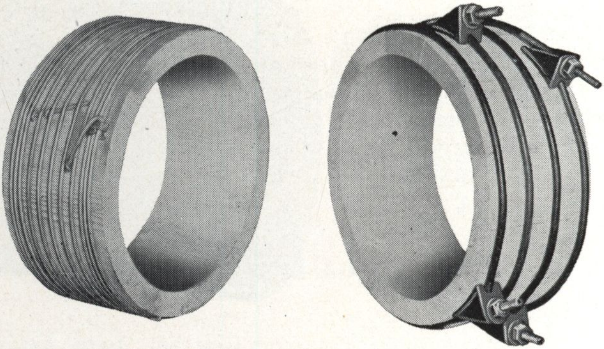
Reinforced Inserted Joint

Reinforced Inserted Joint: For pipé diameters of 14 inches and larger and for 50-foot to 100-foot heads, the banding is omitted for a short length on the mortise end and replaced by one or two round mild steel bands.



Individual Banded Collar

Individual Banded Collar: This type of collar is used on pipe larger than 14 inches diameter and also for repair jobs. Steel bands are used instead of wire.



Machine Banded Collar *Individual Banded Collar*

All Collars on "National Quality" Wood Pipe Are Creosote Pressure Treated

Machine Banded Collars: These wood collars are banded in the same manner as the pipe except that the wire is spaced closer to give 50% greater strength than the pipe banding. The collars are 6 inches in length for pipe 12 inches diameter or less. On high heads and larger pipe, the collars are 8 inches long. They are made to fit on the tenons which are turned on each end of the pipe. One collar is fitted on each piece of pipe at the factory.

The chief difference between the collared pipe and the inserted joint pipe is this: In the inserted joint type a tenon is milled on one end and a mortise reamed out of the other; in the collared pipe a tenon is turned on both ends. The collared type, therefore, has a much thicker tenon than the inserted joint type.

Advantages: The collared joint is stronger, and it is much easier to repair. Where a great many fittings

(valves, crosses, tees, and elbows) are to be used, collared pipe should be specified, as the tenons on the collared pipe are made the same size as the hubs of the cast iron fittings. On long lines of inserted joint pipe where few fittings are to be used, special joints of pipe having a tenon on one end milled to fit the hubs on cast iron fittings can be furnished.

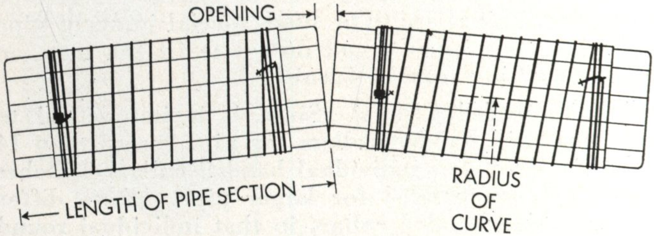
Individual Banded Collars: Since it is impractical to make machine banded collars for pipe larger than 14 inches in diameter, individual banded collars 8 inches long are recommended for larger pipe. These differ from machine banded collars in that individual round mild steel bands are used instead of wire. Four to eight bands are used, depending upon the size of the pipe and the pressure to be held. These bands have a button head on one end and a cold rolled thread, washer, and nut on the other. The button head end is hooked on the under side of a malleable iron shoe; the thread end, after encircling the outside of the pipe, is fitted into the upper side of the shoe. By tightening the nut the band can be adjusted as desired.

Individual banded collars can be used to advantage should it become necessary to repair a joint originally fitted with machine banded collars. The joint of pipe can be slipped into place, the individual banded collars taken to pieces, then built up again around the joint and cinched into position.

Cast Iron or Steel Collars: These collars have application in extremely high pressure pipe or where some other engineering requirement dictates their use. They can be furnished in any type of metal when required.

"National Quality" wood pipe will deliver water year after year for less money than any other kind of pipe.

Curvature: The table below shows the curvature obtained by specified lengths of pipe with the given opening at the joint. It would be well to avoid the use of



any radius calling for an opening greater than one-quarter of an inch, and in order to accomplish this result, short lengths should be ordered for the head under which the curvature occurs.

Radius of Curve

Inside Diameter of Pipe

Length of Pipe, Section, feet	2	3	4	5	6	8	10	12	14	16	18	20	22	24
Opening ⅛ Inch														
2	64	80	98	114	132	164	196	230	262	296	328	362	394	426
3	96	120	147	171	198	246	294	345	393	444	492	543	591	639
4	128	160	196	228	264	328	392	460	524	592	656	724	788	852
5	160	200	245	285	330	410	490	575	655	740	820	905	985	1065
6	192	240	295	342	396	492	588	690	786	888	984	1086	1182	1278
Opening ¼ Inch														
2	32	40	49	57	66	82	98	115	131	148	164	181	197	213
3	48	60	74	86	99	123	147	173	197	222	246	272	296	320
4	64	80	98	114	132	164	196	230	262	296	328	362	394	426
5	80	100	123	143	165	205	245	288	328	370	410	453	493	533
6	96	120	147	171	198	246	294	345	393	444	492	543	591	639
Opening ⅜ Inch														
2	22	27	33	38	44	55	66	77	88	99	110	121	132	142
3	32	40	49	57	66	82	98	115	131	148	164	181	197	213
4	43	54	66	76	88	110	131	152	175	196	219	242	263	284
5	54	67	82	95	110	137	164	192	219	247	274	302	329	355
6	64	80	98	114	132	164	196	230	262	296	328	362	394	436

Machine banded pipe is curved by using straight sections of short length and springing the pipe in the collar until it attains the desired position; therefore, the curves should have radii as great as possible in all cases.

The pipe is shipped in random lengths from 4 feet to 20 feet long, and as a rule there are sufficient short lengths to go around the curves. The shortest lengths should always be used on the curves having the shortest radii, and the longer lengths should always be used on the tangents.

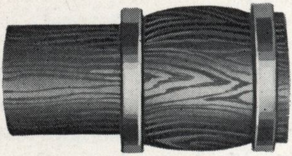
Where there are numerous short curves, either vertical or horizontal, in the pipe line, it is well to have a special assortment of short lengths shipped for each particular curve, which enables the crew to make much better progress in laying the pipe.

It will be noted from the illustration on the opposite page that in machine banded pipe all of the curvature is accomplished at the joint and that the shorter the joint, the less opening there is between the abutting ends of the pipe. The short sections are finished in exactly the same manner as the long ones.

Installation: In hauling and distributing the pipe care should be taken, as unnecessarily rough handling results in damaged collars or tenons which slows up the crew and results in higher cost of installation.

The very finest grade of materials and workmanship enter into the manufacture of "National Quality" pipe. When properly installed the pipe will give a long and efficient life.

Where the pipe is to be buried, the ditch should be dug to an even grade and the bottom freed from large rocks and roots so as to give the pipe a uniform bearing.



Driving Plug

Before driving the pipe together, remove from the inside of the mortise all rocks and dirt. Guide the tenon into the mortise so that the pipe will drive true.

Where small pipe is used, a heavy sledge hammer and a driving plug are all the tools that are necessary. For large pipe use a heavy wooden ram for driving the pipe together. Insert the driving plug into the end of the pipe to be driven and use the hammer or ram so that the blow will fall on the center of the driving plug. Drive the pipe until the joint is tight.

Move each length of pipe into its proper alignment before driving the next length. When driving, keep the driving plug tightly against the end of the pipe.

If the pipe coating is scraped off during handling or installation, the abraded portion should be repainted with coal tar before the pipe is backfilled.

On large sizes of pipe where individual banded collars are used it is not necessary to drive the joints together. The bands on the collar are loosened sufficiently to allow the collar to be slipped over the tenon on the end of the pipe. The next joint of pipe is then moved into position and the tenon slipped into the collar, after which the pipe is moved into its proper alignment and the collar bands tightened. In ditches it is

sometimes found economical to use a socket wrench with a long handle for tightening collar bands. The handle on this wrench should be long enough to allow the operator to stand on the bank. All bands should be tightened to produce uniform bearing and tension.

Filling Pipe Line: Maximum water-tightness in a wood pipe is accomplished when the staves are completely saturated. The pipe should be gradually filled under a low pressure and allowed to stand until the wood staves have a chance to swell and make all joints water-tight. The amount of time required for the staves to become saturated is longer for creosoted pipe than for untreated pipe.

The installation of "National Quality" machine banded pipe is not a difficult job; however, it can be done faster and better by men who are experienced in this class of work. On large projects we are prepared to contract for pipe lines erected, ready for use. Where desired on small projects we can furnish one of our construction superintendents to supervise the work of local labor.

"National Quality" Machine Banded Pipe on Suspension Bridge

"National Quality" Machine Banded Pipe

It is possible in an emergency, as illustrated above, to install machine banded pipe in a wet ditch. With other types of pipe it would be necessary to remove the water.

STANDARD PIPE SPECIFICATIONS

On the pages 49 to 51 will be found specifications covering the manufacture and installation of "National Quality" machine banded wood pipe. These specifications can be safely used for any ordinary water works project. Where special difficulties are encountered, we will be pleased to assist you in drawing up specifications covering your particular requirements.

STANDARD SPECIFICATIONS

MATERIAL AND MANUFACTURE OF "NATIONAL QUALITY" MACHINE BANDED WOOD STAVE PIPE

STAVES

All lumber shall be Douglas Fir. Staves for untreated pipe shall be sound and free from sap, decay, dry rot, injurious checks, wind shakes, wane, loose or rotten knots, large pitch pockets, and other imperfections which might impair the strength, durability or usefulness for the construction of a water-tight pipe line. Cross grain shall not have a slope in excess of one inch in eight inches. Pitch seams shall be limited to those extending not more than one-quarter way through the staves and not more than four inches long. No through knots or knots at edges of staves will be allowed. Sound knots not exceeding one-half inch in diameter appearing on one face only and not falling within the above limitations will be allowed. All lumber used shall be thoroughly and properly seasoned either by air drying or kiln drying before being milled to the pipe stave pattern. All staves shall have the inside and outside faces accurately milled to the true required circular arcs, and the edges shall be milled to the true radial lines and one edge shall be fitted with a small groove and the opposite edge shall be fitted with a tongue of corresponding size. Sap wood shall not be considered a defect in staves for creosoted pipe.

CREOSOTING

All staves to be creosoted shall be thoroughly seasoned and milled to the pipe stave pattern before treatment. The treatment shall be by the vacuum and pressure process and a sufficient quantity of oil shall be forced into the wood to insure an average net retention of eight pounds of creosote oil per cubic foot of wood after the final vacuum has been drawn. The entire process shall be carried on in such a manner as to guarantee the treatment specified without warping or otherwise damaging the staves and leave them free from excess surface oil.

BANDING

The wire used in banding the pipe shall be heavily galvanized mild steel pipe banding wire having a tensile strength of from 55,000 to 65,000 pounds per square inch of cross section. When banding the pipe, a sufficient tension shall be maintained on the wire to impress it slightly into the fibre of the wood without injury. The wire shall be securely fastened at ends of the pipe with clips and staples. The size and spacing of the wire used for banding the pipe shall be such as to provide a factor of safety of four for the pressure under which the pipe is to operate and shall be such as not to impose upon the pipe stave a crushing stress in excess of 800 pounds per square inch based

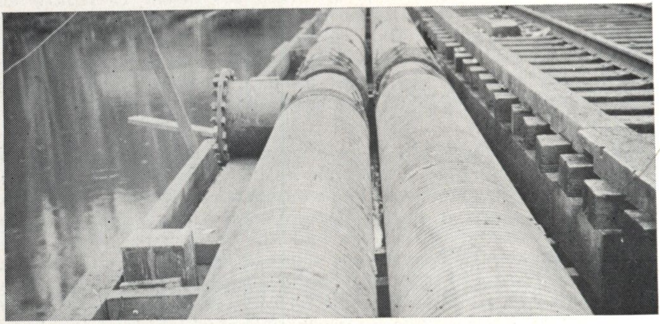
on a projection equal to the radius of the wire, when the pipe is under pressure for which it is designed. At least three wraps of the wire shall be laid tightly together at each end of the pipe section. Banding shall be started by laying the end of the wire so that three or more wraps will lie over it. Banding shall be completed at the other end of the pipe section by laying three wraps in a steel clip designed for this purpose and the end of the wire shall be bent back over the clip after it is closed, and this end shall be stapled to the pipe. The wire shall be stapled approximately every eighteen inches throughout the length of the sections.

COATING OF PIPE

The outside of the pipe shall be dipped in a bath of hot coal tar and coal tar pitch. The coating material shall adhere strongly to the pipe and banding wire and shall not flow or become brittle under ordinary ranges of temperature. Care shall be exercised to keep the coal tar from the tenon ends and inside surfaces of the pipe. After dipping, the pipe and collars shall be rolled in fine sawdust while the coating is still soft.

CREOSOTED WOOD COLLAR COUPLINGS

Couplings shall consist of wood collars fitting snugly over smoothly turned tenons on the ends of pipe sections. Collar staves on both untreated and creosoted pipe shall be preserved as hereinbefore specified under the head "CREOSOTING." The spacing of wire on the machine banded collars shall be such as to provide a strength at least 50% in excess of the wire banding of the pipe with which they are used. The ends of the wire on the machine banded collars shall be securely fastened in the same manner as provided for pipe sections.



Two "National Quality" Machine Banded Pipe Lines 20″ Diameter

STANDARD SPECIFICATIONS

INSTALLATION OF "NATIONAL QUALITY" MACHINE BANDED PIPE

PREPARATION OF THE DITCH

The bottom of the ditch shall be clean, free of all large and sharp stones, and leveled off to make a smooth foundation for the pipe.

LAYING PIPE

The pipe shall be placed into the ditch with care so as to avoid unnecessary injury to the coating and joints, and any part of the coating that has been damaged in handling shall be retouched with coal tar. The joints of pipe shall be firmly driven together. On small pipe, 6 inches in diameter and under, a driving plug and maul may be used. On pipe 8 inches and larger, a driving plug and ram may be used. In making curves short joints shall be used and the joint shall be driven in place in a straight line and then sprung over on the curve.

BLOCKING

All pipe fittings and pipe on sharp curves shall be adequately blocked to prevent movement due to water pressure.

TESTING

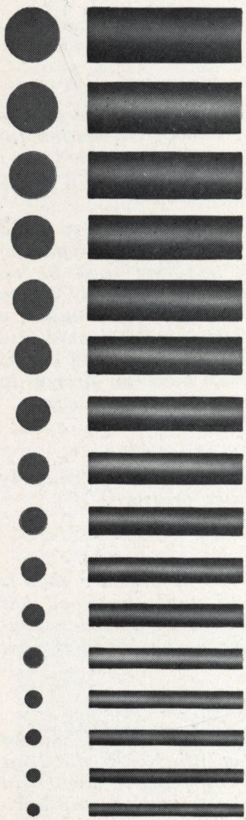
The pipe shall be filled with water under a pressure that is as low as possible and allowed to stand until the wood has become saturated. The pressure shall then be raised gradually to the normal operating head, and running leaks, if any, shall be caulked.

BACKFILLING

The pipe shall be backfilled with material excavated from the ditch, using the finest material and that which has the least organic material to cover the pipe. On pipe 16 inches in diameter and larger, the backfill shall be tamped to the horizontal diameter line. After the pipe is covered with fine material, the balance of the backfill may be made by mechanical means.

Pipe fittings for machine banded pipe and also continuous stave pipe are illustrated on pages 56 to 80.

PIPE WINDING WIRE TABLE

Full Sizes of Plain Wire	Steel Wire Gage* No.	Sizes of Wire: Common Fractions	Sizes of Wire: Decimally	Pounds per Foot	Feet to Pound
	1		.2830	.2136	4.681
		9/32	.28125	.211	
	2		.2625	.1838	5.441
		1/4	.250	.1667	
	3		.2437	.1584	6.313
	4		.2253	.1354	7.386
		7/32	.21875	.1276	
	5		.2070	.1143	8.750
	6		.1920	.0983	10.17
		3/16	.1875	.0937	
	7		.1770	.0835	11.97
	8		.1620	.070	14.29
		5/32	.15625	.0651	
	9		.1483	.0586	17.05
	10		.1350	.0486	20.57
		1/8	.1250	.0416	
	11		.1205	.0387	25.82
	12		.1055	.0296	33.69
		3/32	.09375	.0234	
	13		.0915	.0223	44.78
	14		.0800	.0170	58.58
	15		.0720	.0138	72.32
	16	1/16	.0625	.0104	95.98

*A. S. & W. Gage

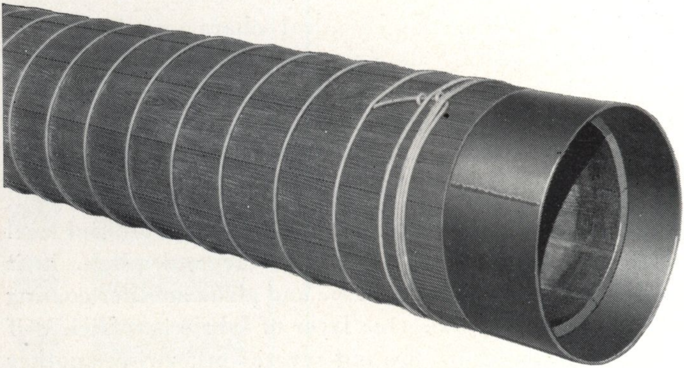
"National Quality" machine banded wood stave pipe will deliver water year after year cheaper than pipe made of any other material. It has adaptability, long life, and low cost. It is entirely free from scale and tuberculation.

Fabric Pipe Covering: When the chemical characteristics of the soil are detrimental to the life of the wire used in banding wood pipe or where the pipe is to be used in salt marshes, a fabric pipe covering is recommended. This is a very heavy covering, which is built up as follows:

After the pipe is banded with heavily galvanized steel wire and coated with hot coal tar and pitch, it is wrapped with a suitable fabric and given another coating of coal tar and pitch. One layer of fabric is sufficient if operating conditions are not severe; otherwise, another layer of fabric is applied and the tar and pitch coating repeated. Finally, the pipe is rolled in fine sawdust.

The fabric serves as a reinforcement for the three applications of tar and pitch and builds up a very heavy coating which thoroughly protects the wire from the action of salt or other chemicals that may be in the ground.

"National Quality" Machine Banded Pipe



"National Quality"
Low-Pressure Creosoted Douglas Fir Irrigation Pipe

This type of pipe makes an excellent installation in irrigation systems where the maximum head does not exceed 40 feet. It is made the same as other types of "National Quality" machine banded pipe except that the staves are thinner.

The staves are creosote treated by the pressure process which makes the pipe immune to decay. This pipe is fitted with steel collars.

"National Quality" low-pressure irrigation pipe is light, easily installed, and will carry much more water than irrigation pipe made of other materials. It is always entirely free from rust, scale, and tuberculation; therefore, it will retain its high carrying capacity throughout its service life. Roots will not grow through the joints of this creosoted pipe. It is flexible and will withstand settlement of the ground without cracking.

This pipe is made in sizes from 3″ to 12″ inside diameter and banded for a maximum head of 40′.

WOOD PIPE

Wood pipe is being specified today to replace pipe lines made of other materials where clean water, free from rust, scale and discoloration, is desired for domestic use and demanded for industrial purposes.

Wood pipe has a long useful life. We are now replacing plain, untreated fir pipe lines that were installed more than 30 years ago. These old pipe lines were not as good as those we are producing today; however, they served their purpose well and were maintained by the same number of men required to take care of lines made of more expensive pipe materials.

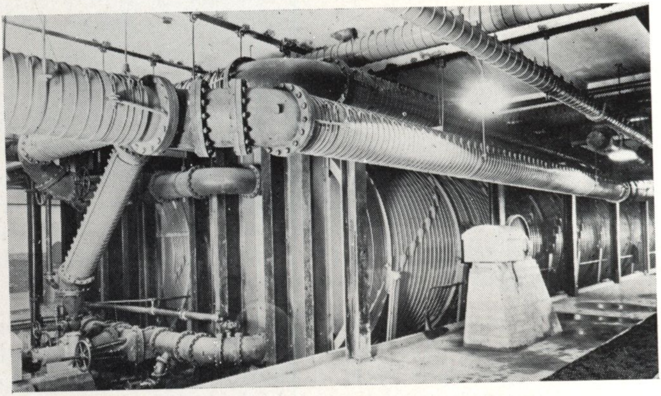
Creosote pressure treated water pipe has not been in use as long as the untreated pipe; however, treated culvert pipes that have been in use for over 42 years are still in excellent condition, which indicates that the creosote pressure treated water pipe should have a useful life of at least 50 years.

A wood pipe will usually outlast the requirements of the original pipe line design for it is often found necessary, after a period of time, to make some changes in the size of the pipe lines, change the grade or alignment, or even go to a new source of supply of water. *It is very easy* to pay too much for so-called permanence and build up a bonded indebtedness that cannot be met before changing conditions make the general design of the project obsolete.

The cost of wood pipe is so much less than that of other types of standard water pipe that the saving, capitalized, will more than cover all maintenance costs and costs of complete replacement when the pipe has outlived its usefulness.

Wood pipe has adaptability, long life, and low cost. It remains free from scale and tuberculation.

WOOD PIPE FITTINGS



A "National Quality" Pipe Installation

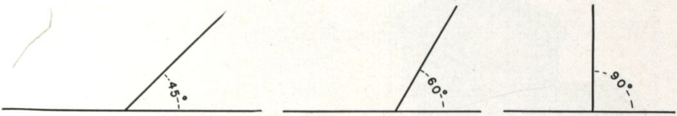
On the following pages will be found illustrated and described fittings for both machine banded and continuous stave pipe.

Wood Pipe Reducer

When it is required to reduce from one size of pipe to another, we are prepared to furnish a tapered piece of wood pipe to accomplish the reduction. It is about five feet long for each two inches of reduction of pipe diameter. This makes a very efficient and economical reducer.

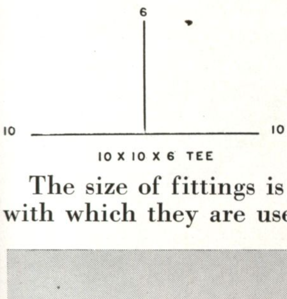
How to Describe Cast Iron Fittings

The angle of a bend or elbow is measured by the angle of deflection from a straight line, thus:

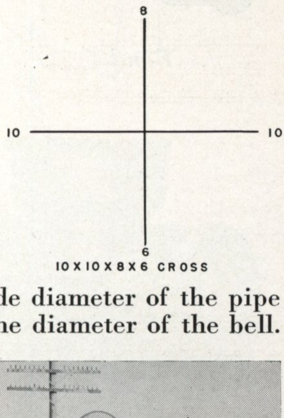


45° 60° 90°

In describing tees and crosses, the run or main line is read first and then the outlets or branches, thus:

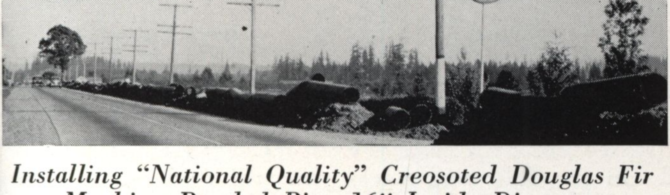


10 X 10 X 6 TEE



10 X 10 X 8 X 6 CROSS

The size of fittings is the inside diameter of the pipe with which they are used, not the diameter of the bell.

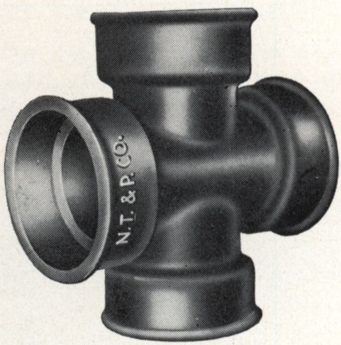


Installing "National Quality" Creosoted Douglas Fir Machine Banded Pipe 16″ Inside Diameter

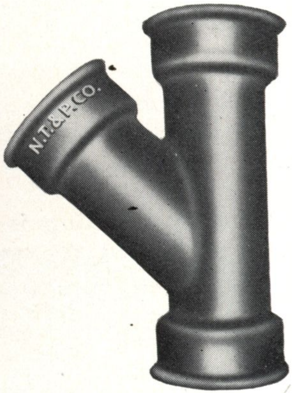
"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

Bend

Tee



Cross

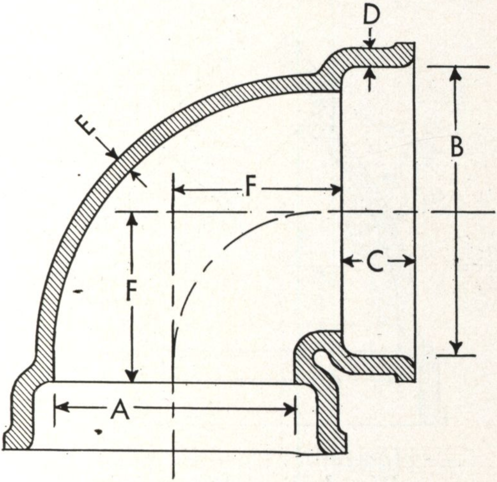


Wye Lateral

These fittings are lighter than the usual cast iron pipe fittings for the reason that they are not unnecessarily long. They are designed especially for wood pipe.

On the following pages you will find tables giving dimensions and weights.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

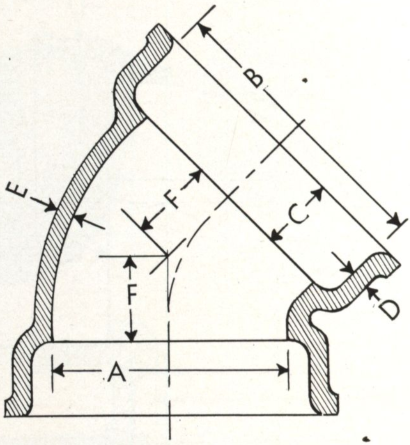


Wood Pipe 90° Bends

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Center to Hub Inches	Approx. Weight Lbs.
A	B	C	D	E	F	
2	3 ¾	3	½	⅜	3	22
3	4 ¾	3	½	⅜	3 ½	26
4	5 ¾	3	½	⅜	4	35
5	6 ¾	3	½	½	4 ½	55
6	7 ¾	3	½	½	5	60
8	9 ¾	3	¾	⅝	6	120
10	11 ¾	3	¾	⅝	7	145
12	14	3	¾	⅝	8	160
14	16	4	¾	⅝	9 ½	200
16	18	4	13/16	11/16	11	300
18	20	4	⅞	¾	12	430
20	22	4	15/16	13/16	13	600
22	24	4	1	⅞	14	725
24	26	4	1	⅞	15	850

Wood pipe is not corroded by sulphur or mineral water.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

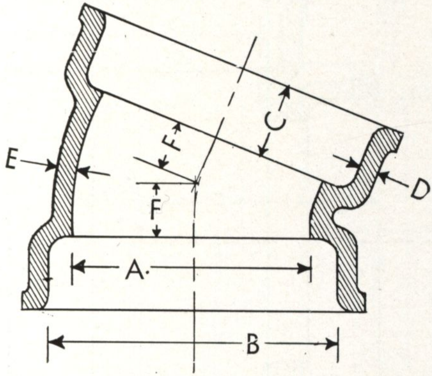


Wood Pipe 45° Bends

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Center to Hub Inches	Approx. Weight Lbs.
A	B	C	D	E	F	
2	3 ¾	3	½	⅜	1 ⅞	20
3	4 ¾	3	½	⅜	2	30
4	5 ¾	3	½	⅜	2 ¼	32
5	6 ¾	3	½	½	2 7/16	36
6	7 ¾	3	½	½	2 ⅝	48
8	9 ¾	3	¾	⅝	3 ⅛	80
10	11 ¾	3	¾	⅝	3 ½	108
12	14	3	¾	⅝	3 ⅞	140
14	16	4	¾	⅝	4 ½	175
16	18	4	13/16	11/16	5 ⅛	250
18	20	4	⅞	¾	5 ½	300
20	22	4	15/16	13/16	6	400
22	24	4	1	⅞	6 ½	500
24	26	4	1	⅞	6 ¾	600

Wood pipe does not taint or affect water flowing through it.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

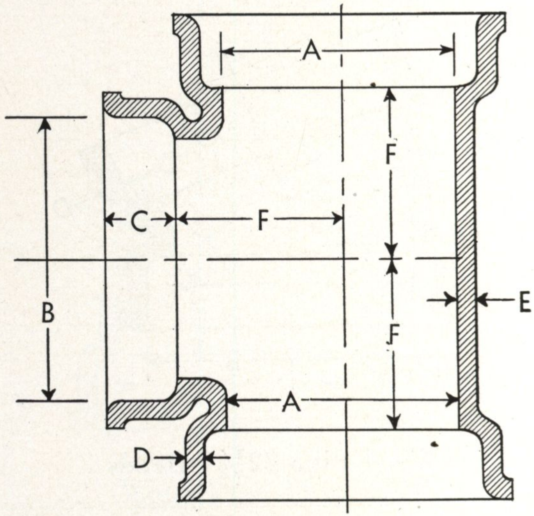


Wood Pipe 22½° Bends

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Center to Hub Inches	Approx. Weight Lbs.
A	B	C	D	E	F	
2	3 3/4	3	1/2	3/8	1 3/8	20
3	4 3/4	3	1/2	3/8	1 7/16	25
4	5 3/4	3	1/2	3/8	1 1/2	30
5	6 3/4	3	1/2	1/2	1 11/16	35
6	7 3/4	3	1/2	1/2	1 13/16	45
8	9 3/4	3	3/4	5/8	1 7/8	70
10	11 3/4	3	3/4	5/8	2 1/4	115
12	14	3	3/4	5/8	2 3/8	130
14	16	4	3/4	5/8	2 3/4	160
16	18	4	13/16	11/16	3	200
18	20	4	7/8	3/4	3 1/4	250
20	22	4	15/16	13/16	3 3/8	350
22	24	4	1	7/8	3 1/2	425
24	26	4	1	7/8	3 3/4	500

Since it is not easily affected by frost, wood pipe can be laid in shallower ditches than other pipe.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

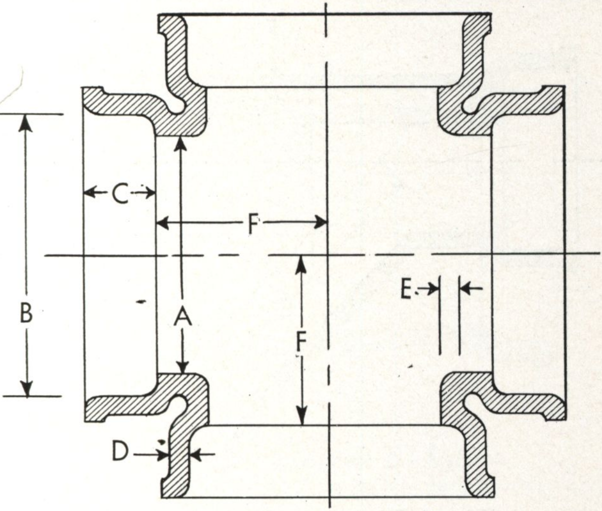


Wood Pipe Tees

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Center to Hub Inches	Approx. Weight Lbs.
A	B	C	D	E	F	
2	3 ¾	3	½	⅜	3	30
3	4 ¾	3	½	⅜	3 ½	36
4	5 ¾	3	½	⅜	4	45
5	6 ¾	3	½	½	4 ½	60
6	7 ¾	3	½	½	5	75
8	9 ¾	3	¾	⅝	6	140
10	11 ¾	3	¾	⅝	7	200
12	14	3	¾	⅝	8	260
14	16	4	¾	⅝	9 ½	350
16	18	4	$\frac{13}{16}$	$\frac{11}{16}$	11	450
18	20	4	⅞	¾	12	550
20	22	4	$\frac{15}{16}$	$\frac{13}{16}$	13	750
22	24	4	1	⅞	14	925
24	26	4	1	⅞	15	1100

Wood pipe is not affected by electrolysis.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

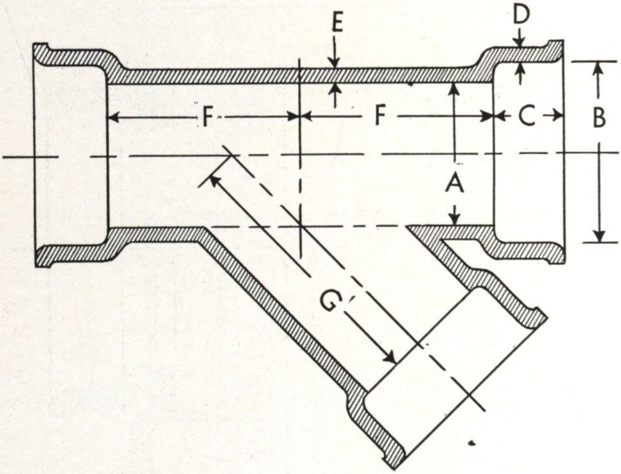


Wood Pipe Crosses

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Center to Hub Inches	Approx. Weight Lbs.
A	B	C	D	E	F	
2	3 ¾	3	½	⅜	3	35
3	4 ¾	3	½	⅜	3 ½	45
4	5 ¾	3	½	⅜	4	55
5	6 ¾	3	½	½	4 ½	70
6	7 ¾	3	½	½	5	105
8	9 ¾	3	¾	⅝	6	175
10	11 ¾	3	¾	⅝	7	250
12	14	3	¾	⅝	8	300
14	16	4	¾	⅝	9 ½	400
16	18	4	$\frac{13}{16}$	$\frac{11}{16}$	11	550
18	20	4	⅞	¾	12	700
20	22	4	$\frac{15}{16}$	$\frac{13}{16}$	13	900
22	24	4	1	⅞	14	1150
24	26	4	1	⅞	15	1400

Wood pipe is not destroyed by acids or salts.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE

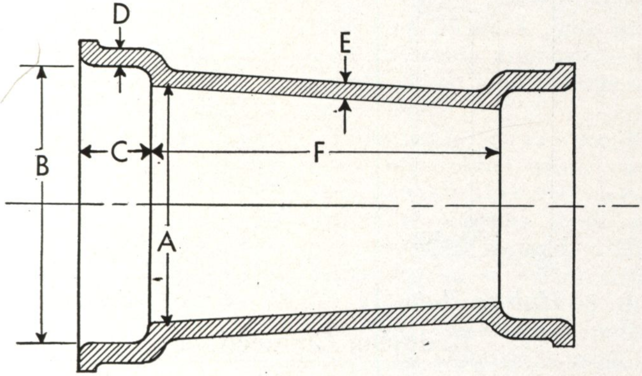


Wood Pipe 45° Wye Lateral

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Length Inches		Approx. Weight Lbs.
A	B	C	D	E	F	G	
2	3 3/4	3	1/2	3/8	5 7/8	6 1/4	34
3	4 3/4	3	1/2	3/8	6 1/2	7 3/8	50
4	5 3/4	3	1/2	3/8	7	8 3/4	75
5	6 3/4	3	1/2	1/2	8 1/4	10	80
6	7 3/4	3	1/2	1/2	7 7/8	10 3/4	110
8	9 3/4	3	3/4	5/8	10 3/4	14 7/8	200
10	11 3/4	3	3/4	5/8	12 3/4	16 3/4	300
12	14	3	3/4	5/8	13 1/2	19 3/8	400
14	16	4	3/4	5/8	16	22	600
16	18	4	13/16	11/16	17 1/4	24 1/2	800
18	20	4	7/8	3/4	19 1/4	27	1000
20	22	4	15/16	13/16	20 5/8	29 1/2	1300
22	24	4	1	7/8	22 1/2	32	1550
24	26	4	1	7/8	24	34 3/4	1800

Because of its elasticity, wood pipe does not burst when the water in it freezes.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE



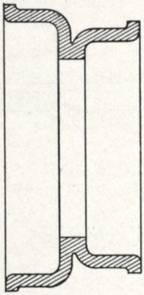
Wood Pipe Tapered Reducers

Inside Diameter Inches	Hub Diameter Inches	Hub Depth Inches	Hub Thickness Inches	Shell Thickness Inches	Length Inches	Approx. Weight Lbs.*
A	B	C	D	E	F	
3	4 ¾	3	½	⅜	7	20
4	5 ¾	3	½	⅜	8	30
5	6 ¾	3	½	½	9	40
6	7 ¾	3	½	½	10	50
8	9 ¾	3	¾	⅝	12	88
10	11 ¾	3	¾	⅝	14	106
12	14	3	¾	⅝	16	152
14	16	4	¾	⅝	19	220
16	18	4	13/16	11/16	22	310
18	20	4	⅞	¾	24	400
20	22	4	15/16	13/16	26	550
22	24	4	1	⅞	28	675
24	26	4	1	⅞	30	800

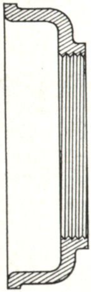
*Weights figured on reducing diameter 2 inches. Special fittings can be made for any reduction in diameter.

Wood pipe requires less labor and experience to lay than other pipe.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE



Hub to Hub

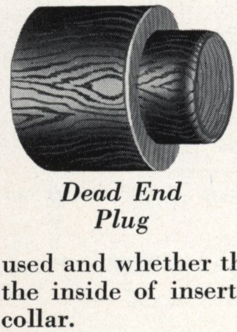


Hub to Screw

Reducing Connections

Inside Diameter Wood Pipe Inches	Approximate Weight, Lbs. Hub to Hub	Approximate Weight, Lbs. Hub to Screw	Inside Diameter Wood Pipe Inches	Approximate Weight, Lbs. Hub to Hub	Approximate Weight, Lbs. Hub to Screw
3 x 2	22	14	10 x 8	88	66
4 x 2	26	18	12 x 10	120	90
4 x 3	28	20	14 x 12	145	110
5 x 3	30	22	16 x 14	170	128
5 x 4	32	24	18 x 16	215	160
6 x 4	35	27	20 x 18	285	225
6 x 5	42	32	22 x 20	345	260
8 x 6	60	50	24 x 22	430	325

DEAD END PLUG



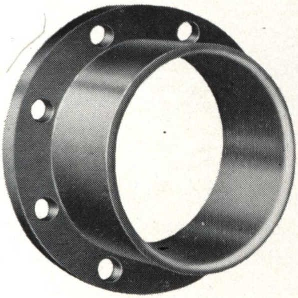
Dead End Plug

Dead end plugs are accurately turned from Douglas Fir and are used for closing the dead ends of wood stave pipe lines for either temporary or permanent installations.

When ordering, please specify the type of machine banded pipe with which these plugs are to be used and whether they are to fit the inside of the tenon, the inside of inserted joint mortise, or the inside of a collar.

HUB TO FLANGE ADAPTER

Hub to flange adapters are used for connecting machine banded pipe to flanged valves and fittings as shown on page 73. The hub is of the same dimensions as for other cast iron fittings on pages 59-65.



Hub to Flange Adapter

These adapters are usually made of welded steel, cast steel, or malleable iron; however, they can be made of acid resisting metal. The flange thickness varies with the kind of metal and the operating conditions under which the adapter is used.

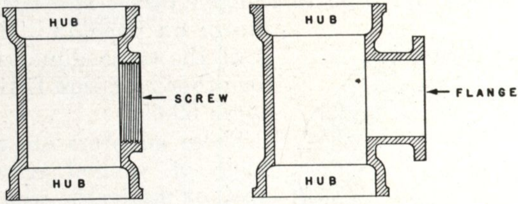
American 125 lb. Cast Iron Flange Standards

Dimensions in Inches

Size	Diameter of Flanges	Thickness of Flanges	Diameter Bolt Circle	Number of Bolts	Size of Bolts
2	6	5/8	4 3/4	4	5/8
3	7 1/2	3/4	6	4	5/8
4	9	15/16	7 1/2	8	5/8
5	10	15/16	8 1/2	8	3/4
6	11	1	9 1/2	8	3/4
8	13 1/2	1 1/8	11 3/4	8	3/4
10	16	1 3/16	14 1/4	12	7/8
12	19	1 1/4	17	12	7/8
14	21	1 3/8	18 3/4	12	1
16	23 1/2	1 7/16	21 1/4	16	1
18	25	1 9/16	22 3/4	16	1 1/8
20	27 1/2	1 11/16	25	20	1 1/8
22	29 1/2	1 13/16	27 1/4	20	1 1/4
24	32	1 7/8	29 1/2	20	1 1/4
26	34 1/4	2	31 3/4	24	1 1/4
28	36 1/2	2 1/16	34	28	1 1/4
30	38 3/4	2 1/8	36	28	1 1/4
36	46	2 3/8	42 3/4	32	1 1/2
42	53	2 5/8	49 1/2	36	1 1/2
48	59 1/2	2 3/4	56	44	1 1/2
54	66 1/4	3	62 3/4	44	1 3/4
60	73	3 1/8	69 1/4	52	1 3/4

These drilling Templates are in multiples of four, so that fittings may be made to face in any quarter and bolt holes straddle the center line. Bolt holes are drilled 1/8 inch larger than nominal diameter of bolts.

"NATIONAL QUALITY" CAST IRON FITTINGS FOR MACHINE BANDED WOOD STAVE PIPE



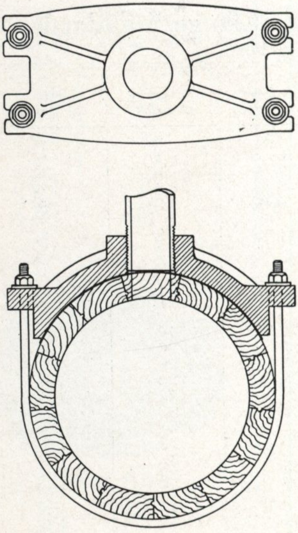
Wood Pipe Tees with Screw and Flange Outlets

We are prepared to furnish special cast iron fittings with any combination of hub, screw or flange outlets.

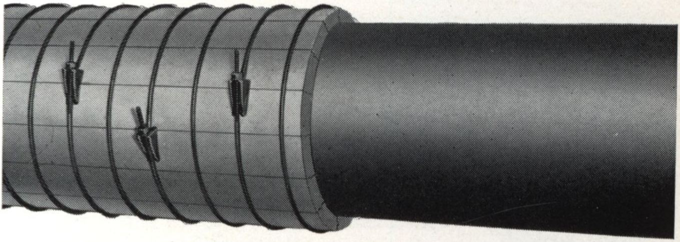
PIPE SADDLES

When ordering saddles for existing pipe lines, let us know the outside circumference of the pipe and the pressure under which the pipe line is operated.

Installation: Before installing saddle, staple the pipe banding more securely for a distance of at least one foot on each side of the proposed saddle location. Cut the banding wire in the center of the space to be occupied by the saddle, then wrap the loose ends tightly around the pipe adjacent to the saddle location, fastening with staples. Clean off surface of pipe, put a soft rubber gasket under saddle and cinch into position with saddle bands.



Wood Pipe Saddle

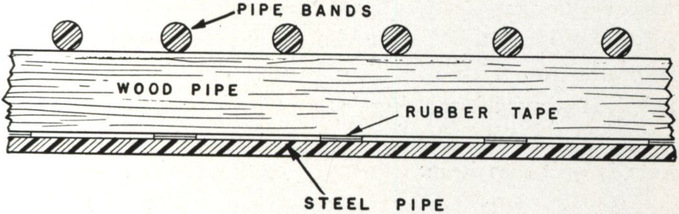


Wood Pipe to Steel Connection

The above illustration shows a very efficient and economical way of connecting wood pipe and steel pipe lines together. The wood pipe is placed over the outside of the steel pipe. Where the connection is made, the outside diameter of the steel pipe should be the same as the inside diameter of the wood pipe.

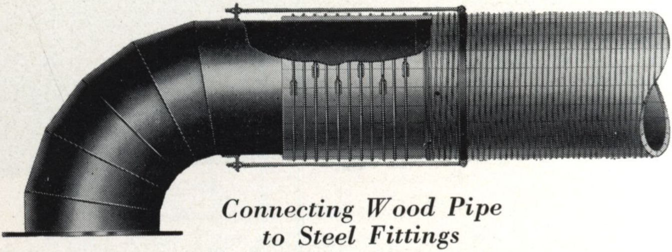
The steel pipe should be as smooth as possible. If found necessary, chip off the outside welds or projections. The pipe should then be painted with a good asphalt paint to prevent rust.

To make a watertight connection two layers of soft rubber electrician's tape should be wrapped around the



pipe directly over each other, not spirally wrapped. These wrappings of tape should be spaced about two inches center to center.

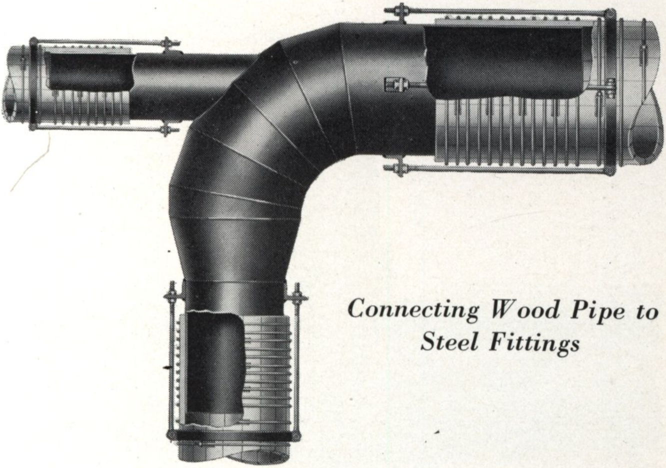
Wood pipe is then built around the steel pipe and cinched into position with pipe bands which should be spaced about one and one-half to two and one-half inches center to center, depending upon the size of pipe and the pressure to be withstood.



Connecting Wood Pipe to Steel Fittings

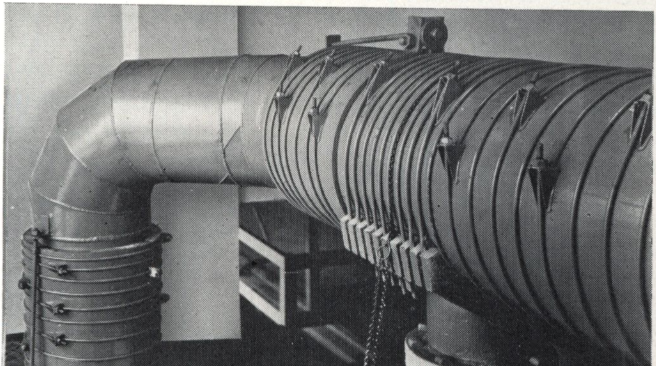
Machine banded pipe can be connected to steel pipe or steel fittings in the same manner as continuous stave. The wire on that part of the wood pipe which extends over the steel fitting is replaced with wood pipe bands. To accomplish this, each turn of wire is stapled back for about a foot. The wire is then loosened and wrapped tightly around the pipe adjacent to the end of the fitting and securely stapled. The fitting is wrapped with rubber tape as explained on page 69, and the wood pipe is then slipped over the steel fitting and cinched into position with the pipe bands. This is a very economical way of making connections, particularly on large pipe where the saving on flanges, bolts and gaskets is quite an item.

Anchor Rods: The size and length of anchor rods for steel fittings vary with the size of pipe, the pressure under which the pipe is operated, and the angle of the bend. We will be pleased to assist you in the design of fittings and anchors to meet your particular requirements.

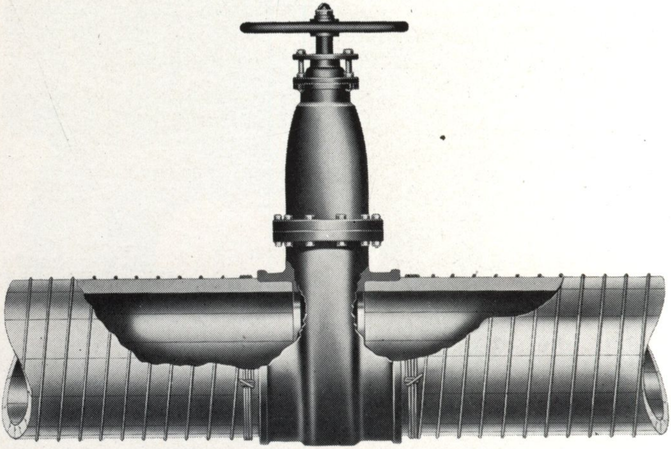


Connecting Wood Pipe to Steel Fittings

The above illustration shows how simple it is to use steel fittings with wood pipe. These steel fittings can be made in any size, with any combination of angles and outlets.



A "National Quality" Wood Pipe Installation



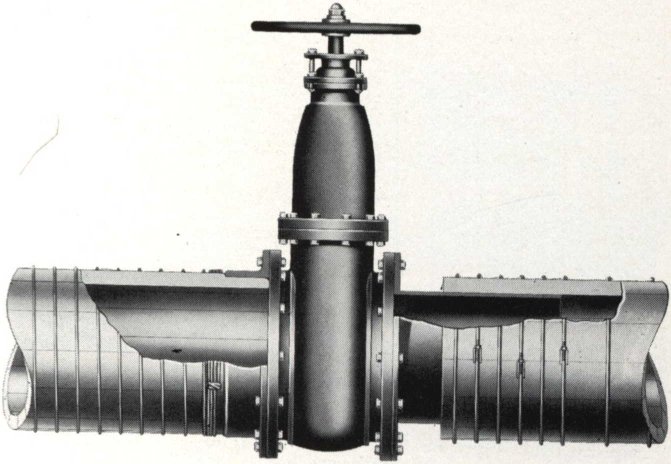
Hub End Gate Valve

Machine banded pipe is connected to a hub end gate valve by driving the tenon of the wood pipe into the valve hub. The swelling of the wood staves makes a tight joint.

Standard hub end gate valves can be used with wood pipe by cutting a tenon to fit the valve hub or ordering lengths of wood pipe with a special tenon on one end for this purpose.

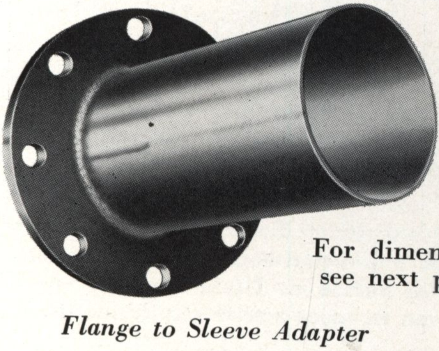
Some valve manufacturers produce hub end gate valves especially designed for use with wood pipe, in which case the valves have hubs of the same dimensions as the hubs of our standard cast iron fittings shown on pages 59 to 65. These hubs are of the proper size to fit over the tenons of our standard collared pipe.

Where inserted joint pipe is connected to a hub end gate valve or a cast iron fitting, it is necessary to cut a tenon on the pipe to fit the hub or to have special joints of pipe shipped with the order for this purpose.



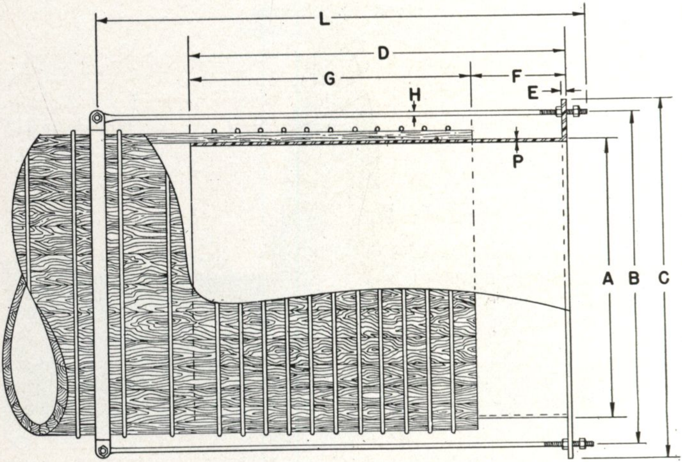
Flanged Gate Valve

Both machine banded and continuous stave pipes are connected to flanged valves by means of adapters. The tenon of the machine banded pipe fits directly into the hub to flange adapter shown on page 67. Continuous stave pipe is connected to the sleeve of the flange to sleeve adapter by using the method employed in connecting wood pipe to steel pipe described on page 69.



For dimensions see next page

Flange to Sleeve Adapter

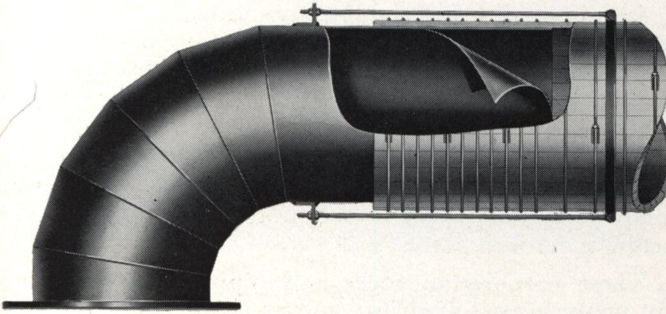


Flange to Sleeve Adapter

Measurements of the Flange to Sleeve Adapter

A	B	C	D	E	F	G	H	L	P
6	9 ½	11	9	⅜	3	6			
8	11 ¾	13 ½	10 ½	½	3 ½	7			
10	14 ¼	16	12	½	4	8			
12	17	19	13 ½	½	4 ½	9			
14	18 ¾	21	15	⅝	5	10			
16	21 ¼	23 ½	16 ½	⅝	5 ½	11			
18	22 ¾	25	18	⅝	6	12			
20	25	27 ½	19 ½	¾	6 ½	13	Variable	Variable	Variable
22	27 ¼	29 ½	21	¾	7	14			
24	29 ½	32	22 ½	¾	7 ½	15			
30	36	38 ¾	24	¾	8	16			
36	42 ¾	46	27	⅞	9	18			
42	49 ½	53	31	1	10	21			
48	56	59 ½	34	1	10	24			

It will be noted that some of these measurements are indicated as variable. Upon request, specific figures will be given to meet actual requirements.



Rubber-lined Steel Fitting for Wood Pipe

"National Quality" wood pipe has a distinct application in industries using chemical solutions. In pulp and paper mills, for example, the pulp is transported with water through pipe lines. Any rust or scale sloughed off metal pipe discolors the pulp and results in serious loss.

"National Quality" wood pipe does not contain anything that can slough off and discolor the water; hence, it is extensively used in pulp and paper mills and chemical industries where liquids must be transported without coming into contact with metal.

When making pipe connections for these installations, it is advisable to use pipe fittings made of acid-resisting metal, or steel which is rubber-lined. It is more economical to use rubber-lined steel fittings, especially for large sizes, as the cost of large fittings made of acid-resisting metal is prohibitive.

The rubber lining is vulcanized to the inside of the steel fittings and allowed to extend over the face of the flanges so that none of the contents of the pipe comes in direct contact with the metal.

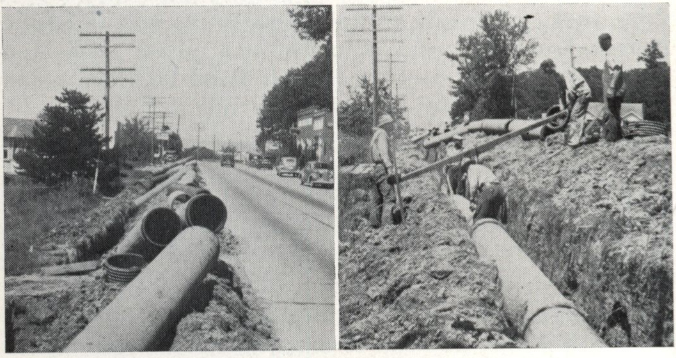
SERVICE CONNECTIONS

Small service connections are usually made with either the brass corporation cock or tapping nipple illustrated on the opposite page. These corporation cocks and nipples have special, sharp thread on the bottom which screws into the wood, and on the top they have standard iron pipe thread.

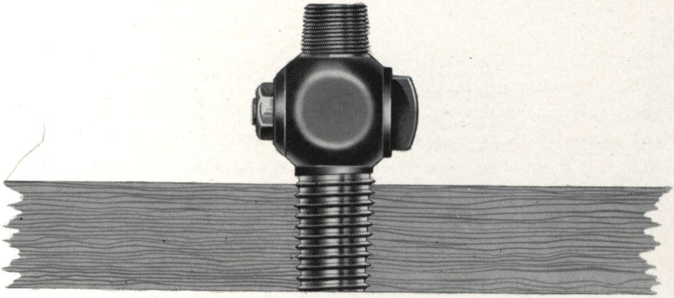
The installation of these cocks and nipples is a very simple matter. Just bore a hole in the pipe stave and screw them into place.

These corporation cocks and nipples are produced by many brass foundries; and as there is no standard diameter for the wood thread, it is advisable to bore a test hole in a board first to determine the proper diameter. It is best to use an expansion bit for this purpose.

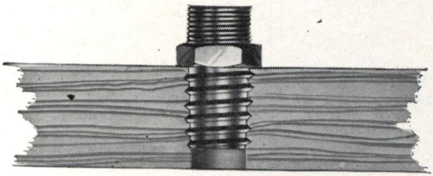
Where larger connections are required, the lock-nut type of connection illustrated on the opposite page or the cast iron saddles or tees illustrated on page 68 can be used.



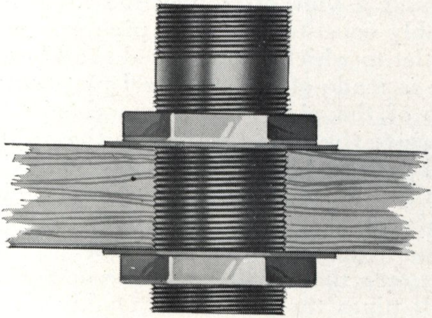
Installing "National Quality" Machine Banded Wood Stave Pipe



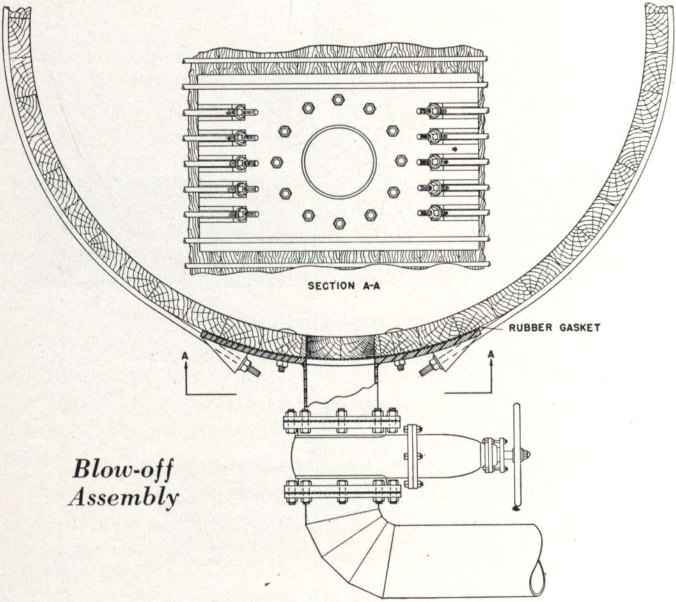
Brass Corporation Cock
for Sizes ½″ to 1½″ Diameter



Brass Tapping Nipple
for Sizes ½″ to 1½″ Diameter



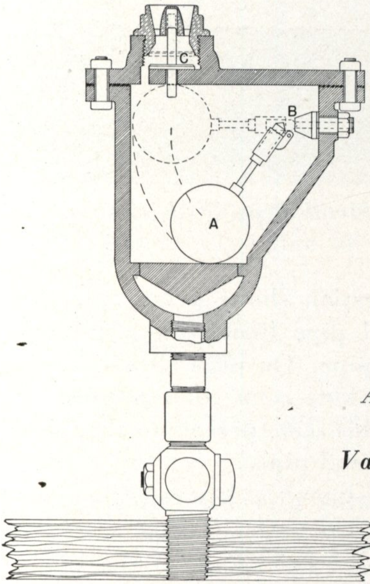
Lock-nut Connection
for Sizes ¾″ to 3½″ Diameter



Blow-off Assembly

The illustration shows an economical and practical way of making a blow-off connection for a large pipe. This assembly consists of a steel pipe saddle having a flanged outlet to which is connected the blow-off valve. The saddle is made of a heavy steel plate curved to fit the outside of the pipe. Lugs are welded to the steel plate to receive the pipe bands, and the saddle is held in position on the pipe with bolts having large oval heads on the inside of the pipe. These bolts can be made of galvanized steel or acid-resisting metal, depending upon the requirements. A soft rubber gasket should be used between the saddle and the wood staves.

For small pipes the blow-off assembly can be made with a cast iron tee or saddle with a nipple and a valve. These tees and saddles are illustrated on page 68.



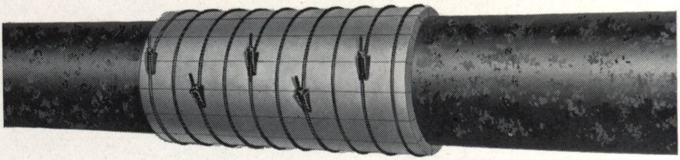
Air Relief and Vacuum Valve

The object of the air and vacuum valve is to release the air which accumulates at high points in the line, and also to protect the pipe from possible collapse due to vacuum.

This valve operates with a float A and needle valve B for the release of air, and an inverted check valve C to relieve the vacuum. The check valve C also operates to release the air from the line while it is being filled.

As the pipe fills, the float A rises, closing the needle valve B and also the check valve C.

When the pipe line is in operation, the air gradually accumulates at the high point. As soon as sufficient air collects to partially fill the body of the valve, the float A lowers of its own weight, opening the valves and allowing the air to escape, in this way keeping the pipe free of air and allowing it to operate at its full capacity.



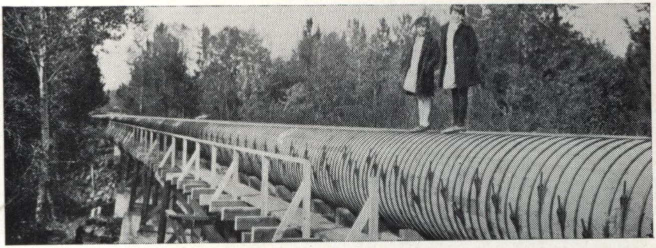
Repairing Metal Pipe With Creosoted Stave Pipe

This illustration shows a very practical way of repairing metal pipe lines with a section of creosoted Douglas Fir pipe. On page 69 will be found the procedure for making connection between wood pipe and steel pipe. This same procedure should be followed in repairing a metal pipe.

When ordering pipe for this purpose, let us know the exact outside circumference of the metal pipe to be repaired and the length of the wood pipe section required. These sections of wood pipe are shipped knocked down.

After the metal pipe has been thoroughly cleaned, painted, and the rubber tape placed around it, as set forth on page 69, the wood staves are built up around the metal pipe and cinched into position with the pipe bands.

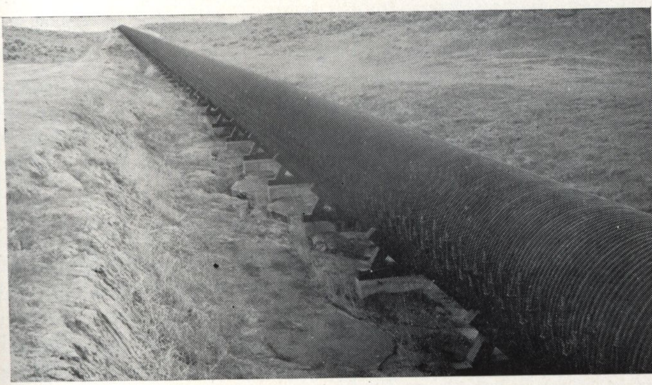
This will make a permanent repair job at very little cost, because the repair can be made without special tools or equipment. It does not require the services of skilled mechanics. Moreover, creosoted wood staves will not decay. Creosoted Douglas Fir culvert pipe that was installed more than forty years ago is still in use today and in very good condition.



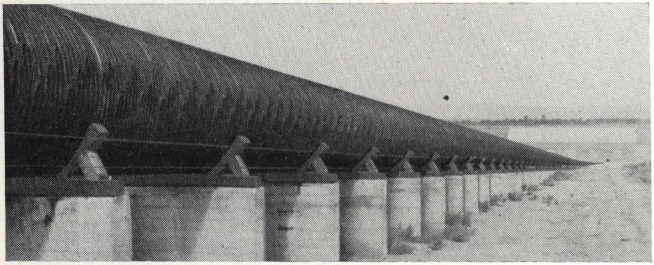
"National Quality"
Untreated Douglas Fir Pipe Line 48″ Diameter

CONTINUOUS WOOD STAVE PIPE

On the following pages will be found illustrated and described "National Quality" creosoted and untreated continuous stave pipe, with standard specifications.



"National Quality"
Creosoted Douglas Fir Pipe Line 60″ Diameter



"National Quality"
Creosoted Douglas Fir Pipe Line 60″ Diameter

Continuous Stave Pipe: The term "continuous stave" is applied to wood pipe which is so constructed that the staves forming the body of the pipe are placed in a continuous line from one end of the pipe to the other, without regard for length of pipe or stave. It is shipped to site of erection knocked down.

"National Quality" continuous stave pipe is made in sizes from six inches to twenty feet inside diameter. This type of construction is used principally for larger sizes, inasmuch as twenty-four inches diameter is as large as it is practical to make machine banded pipe. The smaller sizes, however, have a distinct application in industrial installations.

On the following pages will be found standard specifications covering the manufacture and installation of continuous stave pipe. These specifications can be safely used for any ordinary waterworks project. Where special difficulties are encountered, we will be pleased to assist you in drawing up specifications covering your requirements.

STANDARD SPECIFICATIONS

MATERIAL AND MANUFACTURE OF "NATIONAL QUALITY" CONTINUOUS WOOD STAVE PIPE

STAVES

All lumber shall be Douglas Fir. Staves for untreated pipe shall be sound and free from sap, decay, dry rot, injurious checks, wind shakes, wane, loose or rotten knots, large pitch pockets, and other imperfections which might impair the strength, durability or usefulness for the construction of a water-tight pipe line. Cross grain shall not have a slope in excess of one inch in eight inches. Pitch seams shall be limited to those extending not more than one-quarter way through the staves and not more than four inches long. No through knots or knots at edges or knots within 6 inches of ends of staves will be allowed. Sound knots not exceeding one-half inch in diameter appearing on one face only and not falling within the above limitations will be allowed. All lumber used shall be thoroughly and properly seasoned either by air drying or kiln drying before being milled to the pipe stave pattern. All staves shall have the inside and outside faces accurately milled to the true required circular arcs, and the edges shall be milled to the true radial lines; and one edge shall be fitted with a small groove, and the opposite edge shall be fitted with a tongue of corresponding size. Sap wood shall not be considered a defect in staves for creosoted pipe.

CREOSOTING

All staves to be creosoted shall be thoroughly seasoned and milled to the pipe stave pattern before treatment. The treatment shall be by the vacuum and pressure process, and a sufficient quantity of oil shall be forced into the wood to insure an average net retention of eight pounds of creosote oil per cubic foot of timber after the final vacuum has been drawn. The entire process shall be carried on in such a manner as to guarantee the treatment specified without warping or otherwise damaging the staves and leave them free from excess surface oil.

BANDS

The pipe bands shall be made from round mild steel having an ultimate tensile strength of from 55,000 to 65,000 pounds per square inch of cross section and an elastic limit of one-half the ultimate tensile strength and capability of being bent cold

without fracture 180 degrees around a pin having a diameter equal to the diameter of the test piece. The bands shall have a standard button head on one end and at least 6 inches U. S. standard cold rolled thread, hexagon nut and washer other end. The nut shall be of such thickness as to insure against stripping of the threads and shall be tapped so as to make a snug but easy running fit on the thread. All bands shall have a workmanlike finish, free from any injurious seams, flaws or cracks. All bands, nuts, and washers shall be coated by being dipped in pure asphalt or its equivalent. Rods shall be bent to the required arc and be provided with nuts and washers before dipping. If the bands are dipped cold, they shall be left in the hot bath a sufficient length of time to insure that they have acquired the temperature of the asphalt before removal. The coating shall be so proportioned and applied that it will form a thick and tough coating, free from tendency to flow or become brittle under ordinary ranges of temperature. On large pipe, 5 feet in diameter or over, bands shall be made in two sections, one section having a button head both ends and the other section having thread, nut, and washer both ends. The size and the spacing of the bands shall be such as to provide a factor of safety of four for the pressure under which the pipe is to operate and shall be such as not to impose upon the pipe staves a crushing stress in excess of 800 pounds per square inch, based on a projection equal to the radius of the band, when the pipe is under the pressure for which it is designed. Spacing of bands over butt joints when using steel tongue type of butt joint shall not be more than 6 inches center to center.

PIPE SHOES

The shoes for the pipe shall be of malleable iron, shall be stronger than the rod, and shall have sufficient bearing area to prevent injurious indentation into the staves when bands are cinched. They shall fit accurately to the outer surface of the pipe. The shoes shall be true to pattern and free from blemishes, scale, and shrinkage cracks and have a workmanlike finish. All shoes shall be dipped in pure asphalt or its equivalent.

TONGUES

Tongues shall be made of galvanized steel, 12-gauge in thickness by 1½ inches wide and long enough so that they will penetrate slightly the edges of the adjacent staves. The tongues and the slots in the ends of the staves shall be so proportioned as to insure a snug fit without danger of splitting. The tongues shall be of true rectangular shape, square and smooth and free from ragged edges. All tongues shall be galvanized by the hot dip

process and shall have a coating of not less than 2 ounces of zinc per square foot of double exposed surface.

BUTT JOINTS (Alternate)

Butt joints shall be made from malleable iron and shall be free from blemishes, scale, and shrinkage cracks and have a workmanlike finish. The flanges of the butt joint shall be made to fit the inner and outer circles of the pipe accurately. The butt joint shall have a straight wedge-shaped tongue on each side of the web made to enter a groove of corresponding shape cut in the ends of the staves and shall extend beyond the ends of the web far enough to penetrate the adjacent staves slightly. All butt joints shall be dipped in pure asphalt or its equivalent.

INSTALLATION OF "NATIONAL QUALITY" CONTINUOUS WOOD STAVE PIPE

UNLOADING STAVES

All staves shall be unloaded from the cars and the various lengths put in separate piles. Each pile can have lengths varying not more than 12 inches; that is, staves from 14 to 15 feet long would be placed in one pile.

DISTRIBUTION OF STAVES

Staves shall be taken from the stock pile and distributed along the line in piles, each pile containing the exact number of staves required to make the circle of pipe. Care should be taken to have the staves turned so that the tongue and groove will be in the same position on all staves, thus avoiding the necessity of turning the staves end for end while building the pipe. Staves shall be handled carefully so as to avoid unnecessary damage to them.

ERECTION

The wood stave pipe shall be erected in a workmanlike manner and to the grade established by the engineer in charge of the project. The ends of adjacent staves shall break joints not less than 2 feet. The staves shall be laid and driven in such a manner as to avoid any tendency to crosswind in the pipe, and the required grade and alignment shall be maintained. The staves shall be driven to produce tight butt joints. Driving bars or other suitable means shall be used to avoid marring or damaging the staves in driving. Temporary cradles or other suitable means shall be used in erecting the pipe to insure that it is circular in shape. The barrel of the pipe shall be rounded out to produce smooth interior and exterior surfaces. In rounding out the barrel care shall be taken to avoid damaging

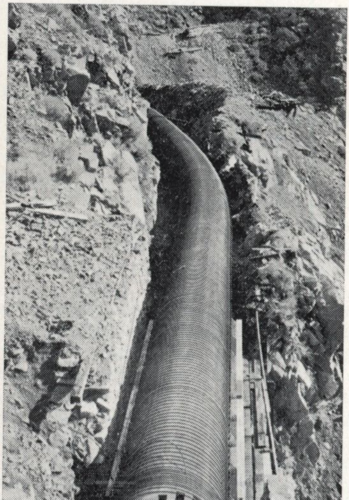
by chisels, mauls, or other tools. The bands shall be accurately spaced in accordance with the schedule of band spacing and shall be placed perpendicular to the axis of the pipe. Pipe shoes shall be placed so as to cover longitudinal joints between staves and bear equally on two staves as nearly as practicable. The shoes shall be placed alternately on opposite sides of the pipe so as to be out of line and to cover successively not less than two longitudinal joints between staves on each side in a uniform manner. The shoes shall not cover butt joints between staves. After the bands are in position and tightened, they shall be cinched again to produce uniform tension throughout the pipe line. All kinks in bands shall be carefully hammered out. All metal work shall be handled with care so as to avoid injury to the coating.

BLOCKING

All pipe fittings and pipe on sharp curves shall be adequately blocked to prevent movement due to water pressure.

TESTING

The pipe shall be filled with water under a pressure that is as low as possible and allowed to stand until the wood has become saturated. The pressure shall then be raised gradually to the normal operating head, and running leaks, if any, shall be caulked.



BACKFILLING

Where pipe is erected in a ditch, it shall be backfilled with material excavated from the ditch. The finer material and that which has the least amount of organic matter shall be used to cover the pipe. The backfill shall be carefully placed and tamped up to the horizontal diameter line of the pipe. After the pipe is covered, it may be backfilled by mechanical means.

"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe
75″ Inside Diameter

HOW "NATIONAL QUALITY" CONTINUOUS STAVE PIPE IS MADE

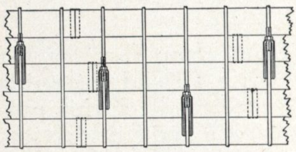
Staves: The staves are made from clear Douglas Fir lumber which first is put through a special seasoning process in dry kilns particularly designed for this purpose. After seasoning and following a rigid inspection, the staves are passed through a pipe stave machine which accurately mills them to pattern so they will exactly fit the pipe for which they are intended. The edges of the staves are provided with a tongue and groove to hold the staves in their exact position and assure a smooth interior. These staves, when finished, are in random lengths of about 7 to 24 feet long.

Butt Joints: Staves are joined end to end by galvanized steel tongues or malleable iron butt joints. In either case the staves are cut off perfectly square, then slotted. Staves that are to receive steel tongues are slotted rectangularly; those to be used with malleable iron butt joints are slotted V-shaped. These slots and respective tongues are so proportioned as to insure a snug fit. See page 89.

The galvanized steel tongues are usually 12 gauge, 1½ inches wide and long enough to penetrate slightly the adjacent staves when the pipe bands are cinched.

"National Quality" malleable iron butt joints are a marked improvement over butt joints used in the past. They not only make a water-tight joint, but brace the ends of the pipe staves on low-pressure pipe where wide band spacing is used. They do not split the staves.

When using the steel tongue type of butt joint, it is customary to reduce the band spacing over butt joints, making a maximum spacing of 6 inches. By using malleable iron butt joints, however, it is unnecessary to vary the band spacing as the butt joints hold the ends of the staves firmly in place. For this reason the malleable iron butt joint has its best application on low pressure pipe.

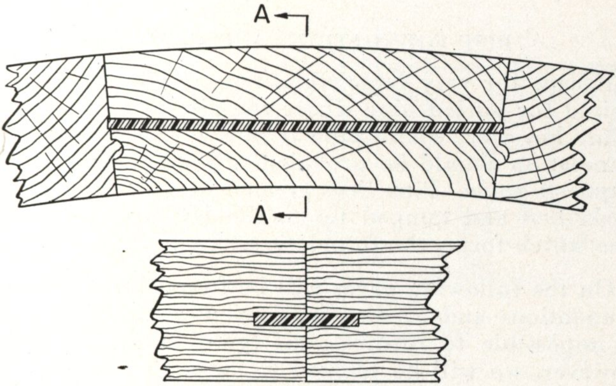


From the illustration it will be noted that the butt joints are staggered, with respect to the butt joints of adjacent staves.

Bands: Continuous stave pipe is banded with round steel pipe bands connected with malleable iron pipe shoes. On small pipe one-piece bands are used which completely encircle the pipe. On large pipe two-piece bands are used as they are easier to handle and have two points where they can be adjusted and tightened.

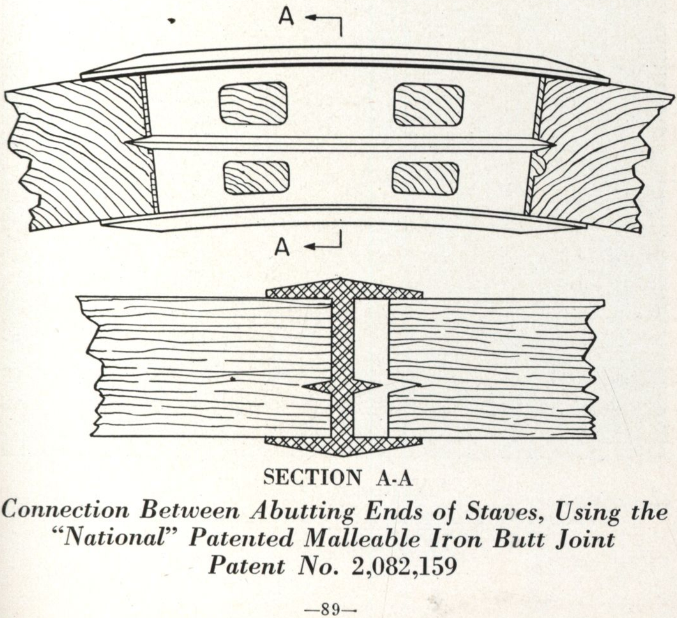
The size and spacing of the pipe bands vary with the pressure and the conditions under which the pipe is to be used.

Where unusual conditions are encountered, we shall be pleased to assist you in preparing specifications for a pipe line which will meet your particular requirements.



SECTION A-A

Connection Between Abutting Ends of Staves, Using the Galvanized Steel Tongue.



SECTION A-A

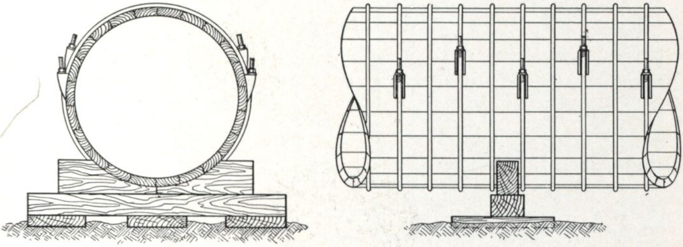
Connection Between Abutting Ends of Staves, Using the "National" Patented Malleable Iron Butt Joint Patent No. 2,082,159

PIPE FOUNDATIONS AND CRADLES

Except for very large diameters, cradles are not required for buried pipe where the ground is reasonably firm; however, where pipe is buried in soft ground, a foundation should be provided to hold the pipe to its required grade. Pipe lines erected in a ditch should be backfilled and tamped up to the horizontal diameter line which forms the foundation.

On the following pages will be found illustrations of foundations and cradles for various sizes of pipe. It is impossible to illustrate all types in limited space; however, we will be pleased to assist in the design of foundation cradles to meet your particular requirements.

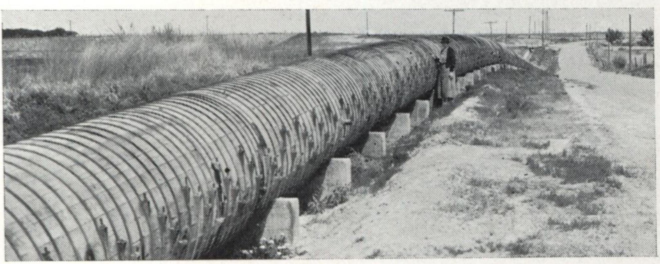
"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe
70″ *Inside Diameter*



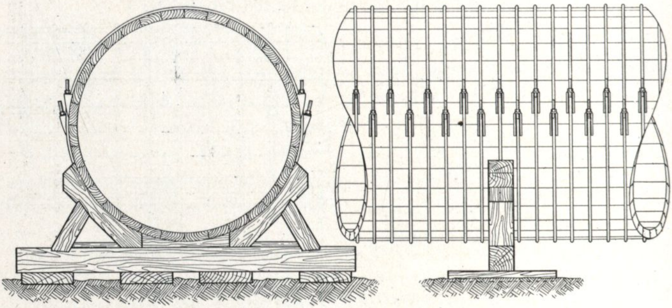
Foundation for Small Pipe

This type of foundation is suitable for the smaller sizes of continuous stave pipe up to about 40 inches diameter. Cradles of this type, when made of creosoted Douglas Fir, provide a permanent installation. The size, length, and number of mud sills required vary with field conditions.

We will be pleased to assist you in the design of cradles to meet your particular requirements.

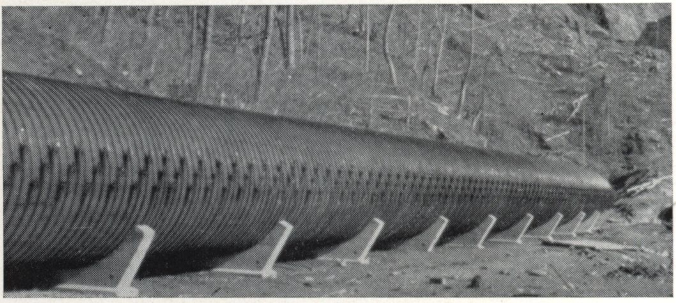


"National Quality" Creosoted Douglas Fir Continuous Stave Pipe 54″ Inside Diameter, with Concrete Cradles

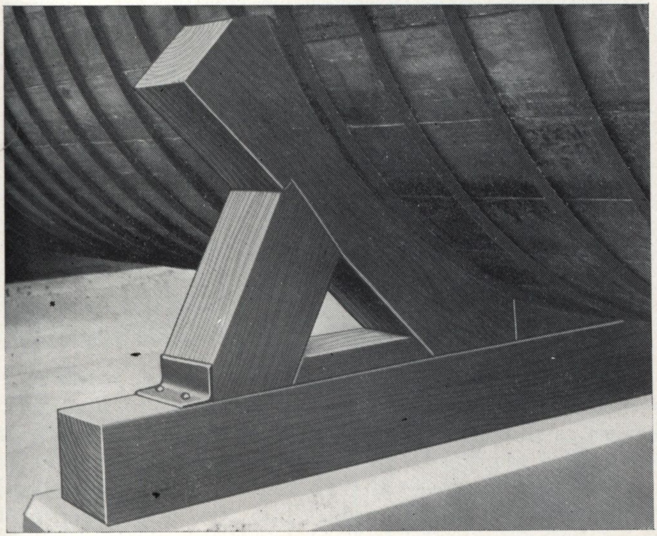


Cradle for Intermediate Pipe Sizes

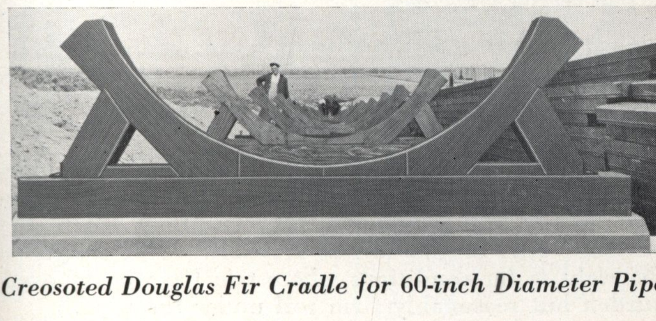
The type of construction shown in the above illustration makes a good cradle for pipe 42 inches to 96 inches diameter. For permanent installations all the lumber should be creosote pressure treated after it is framed to the cradle pattern. The size, length, and number of mud sills required vary with field conditions.



"National Quality" Creosoted Douglas Fir Continuous Stave Pipe 70″ Diameter, with Pre-cast Reinforced Concrete Cradles

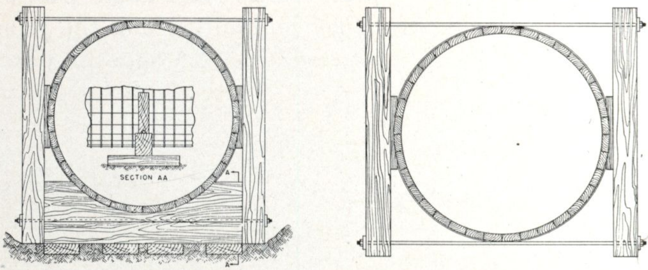


These illustrations show the details of construction of a 60-inch diameter pipe cradle. The angle iron at the bottom of the strut may be omitted and the strut dapped into the sill as illustrated on the opposite page.

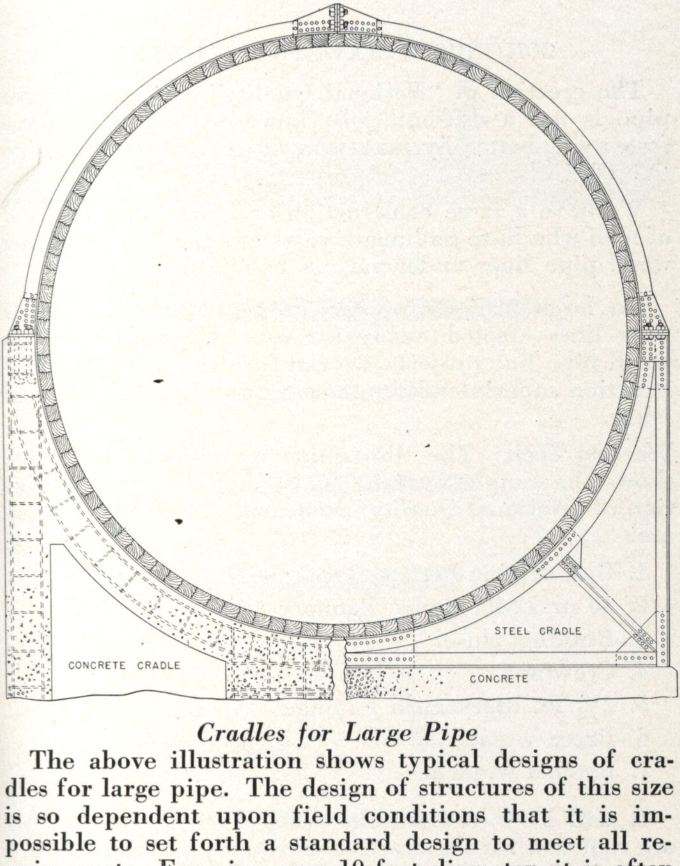


Creosoted Douglas Fir Cradle for 60-inch Diameter Pipe

Where pipe lines are buried in a deep ditch it is sometimes found necessary to reinforce the pipe with braces as shown in the above illustration. This permits the use of standard pipe where otherwise it would be necessary to increase the thickness of the staves and the number of bands used. The size and spacing of these braces vary with field conditions. We shall be pleased to assist you in the design of projects of this kind.



The above illustrations show typical designs for bracing pipe lines subjected to heavy overburden. The design on the left is intended for conditions where the bearing value of the soil is very low. The design on the right is for conditions where you have heavy overburden but reasonably firm soil under the pipe.



Cradles for Large Pipe

The above illustration shows typical designs of cradles for large pipe. The design of structures of this size is so dependent upon field conditions that it is impossible to set forth a standard design to meet all requirements. For pipe over 10 feet diameter, it is often found economical to construct the cradles of reinforced concrete or structural steel.

The illustration shows two types of foundations: On the left, reinforced concrete; on the right, structural steel. In either case, on very large pipe, a structural steel member should extend from the horizontal diameter line over the top of the pipe to hold it in true circular form.

CONTINUOUS STAVE PIPE ERECTION

The erection of "National Quality" continuous stave pipe is not a difficult job; however, it can be done faster and better by men who are experienced in this line of work.

We have a large construction organization composed of men who have had many years of experience erecting wood pipe lines under various conditions.

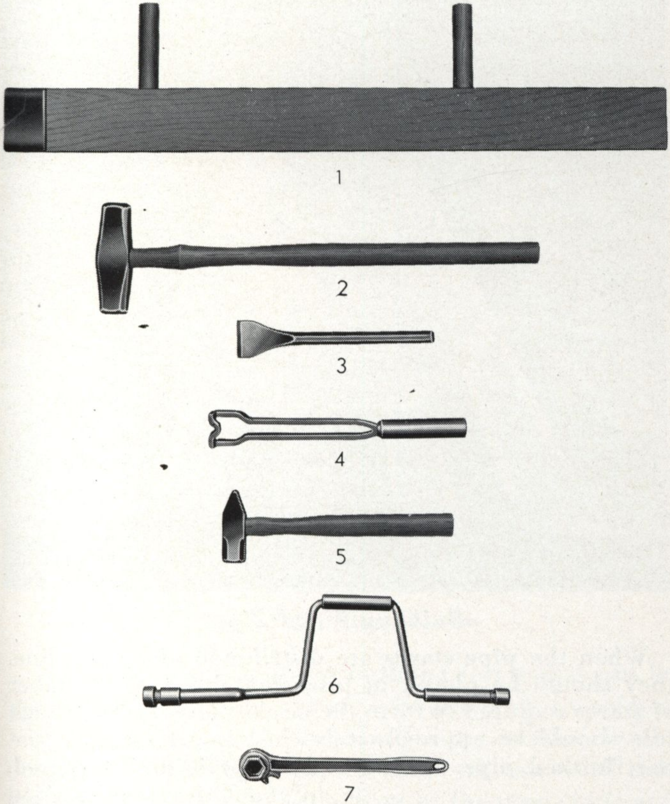
On large projects we are prepared to contract for pipe lines erected, ready for use. Where desired on small pipe line projects, we can furnish one of our construction superintendents to supervise the work of local labor.

Working Tools: The illustration on the opposite page shows the simple working tools required for the erection of "National Quality" continuous stave pipe. They are:

1. Oak driving bar
2. 10 or 12-lb. sledge hammer
3. Building chisel
4. Crowfoot
5. $2\frac{1}{2}$ lb. blacksmith hammer
6. Brace wrench
7. Ratchet wrench.

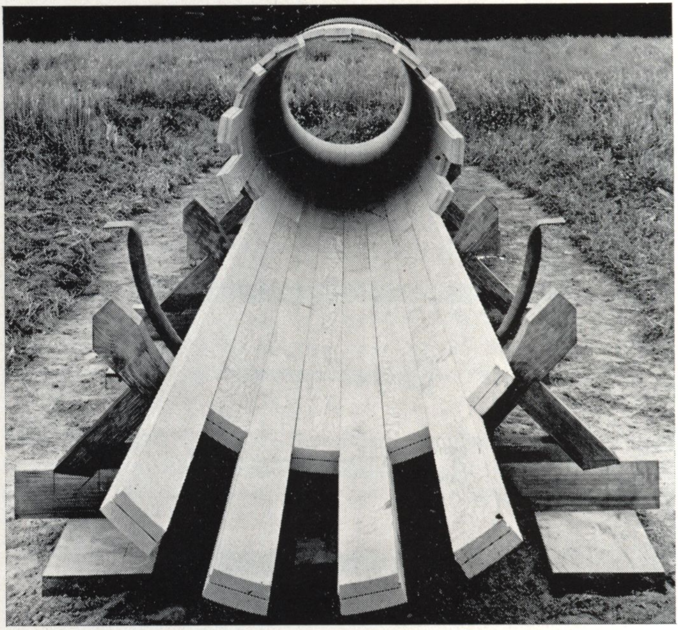
It will be seen from the above that very few tools are required for the erection of wood pipe and that the cost of this equipment as compared to the equipment required for the erection of other types of pipe is very small.

The simplicity with which "National Quality" wood pipe can be hauled, distributed, and erected is one of the reasons why it is being specified on important projects throughout the world.



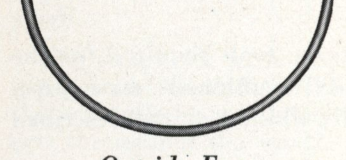
Pipe Erection Tools

These are the simple working tools required for the erection of "National Quality" continuous stave pipe. The use of these tools is fully illustrated and described on the following pages.

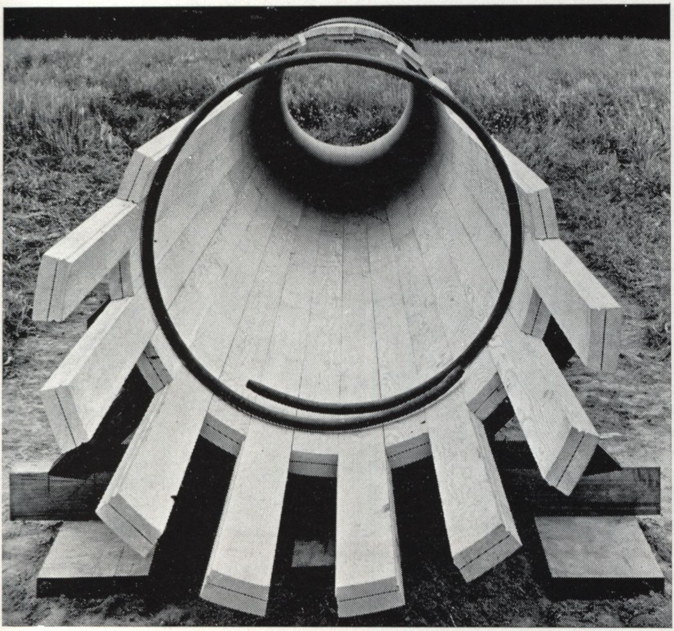


Building Wood Pipe

When the pipe staves are distributed along the line, they should be placed in piles containing the number of staves required to form the circle. The staves in each pile should be approximately the same length so that the finished pipe will have the butt joints, staggered, in about the same location around the pipe. The staves should be placed in the pile so that the tongues will all be on one side, which will eliminate the necessity of the building crew turning some of the staves end for end.

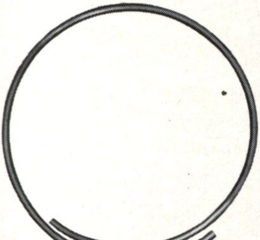


Outside Form



Use of Building Forms

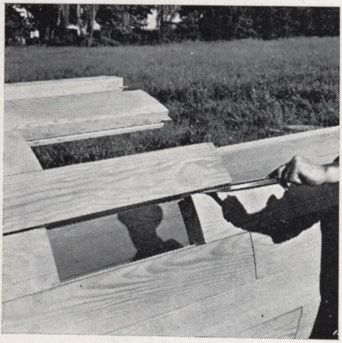
There are many types of building forms that can be used; however, those shown here are now considered standard for the smaller sizes of pipe. They are made of iron pipe bent to the pipe circle and can be produced by any blacksmith or plumber. These forms are used to hold the staves in position until a few bands are placed around the pipe.



Inside Form

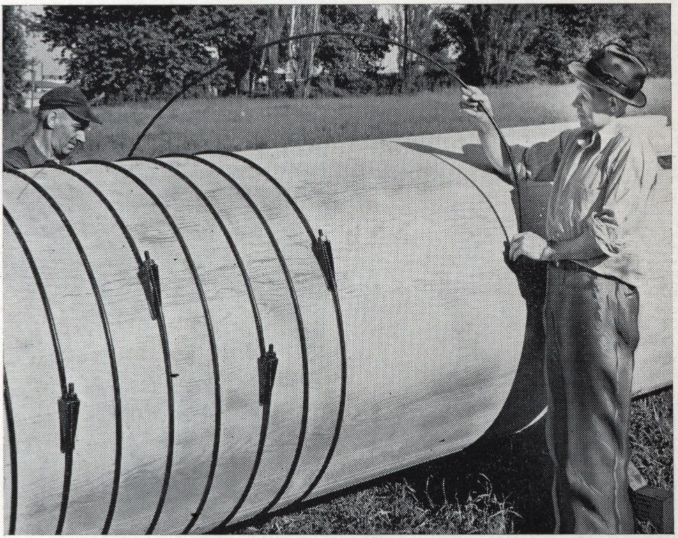
Use of Driving Bar and Sledge Hammer

The driving bar is used to avoid marring or damaging the ends of the staves when they are being driven into position. The driving bar should be about 4 feet long and made of oak or some other hardwood that will withstand considerable hammering, and it should have a steel reinforcing band around one end.



Use of Building Chisel

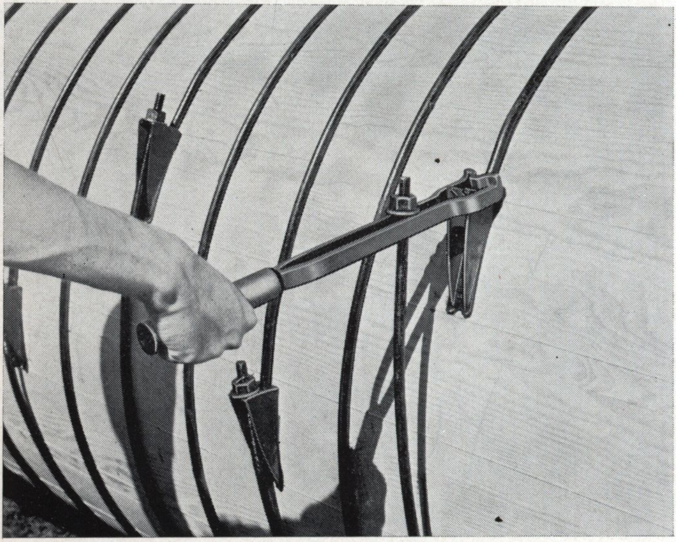
The building chisel is used to guide the staves into their proper position.



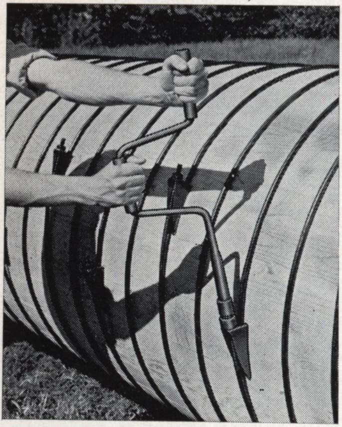
Placing Bands

As soon as a section of pipe is built, a few bands should be placed around it about two or three feet apart. These bands can be placed without regard to their final position. Where one-piece bands are used, they should be placed so as to have the shoes on alternate sides of the pipe. These bands are used to hold the pipe staves in position so that the building forms can be moved forward and the next section of pipe built. The balance of the bands can now be placed on the pipe. They should be accurately spaced in accordance with the schedule of band spacings furnished with the shipment.

The bands should be placed perpendicular to the axis of the pipe with the shoes placed so as to bear equally, as nearly as possible, on two staves. The shoes should be placed alternately on opposite sides of the pipe in a uniform manner. There should be two or more rows of shoes on each side of the pipe, which gives a uniform bearing on a number of staves.



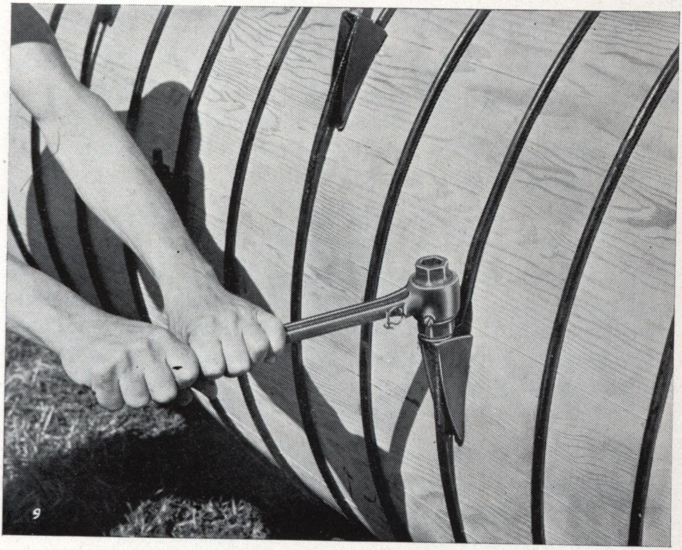
Use of Crowfoot



Use of Brace Wrench

After the band is placed around the pipe, the pipe shoe is slipped over the button head and the crowfoot is used as illustrated to place the threaded end of the band with the nut and washer into position in the pipe shoe.

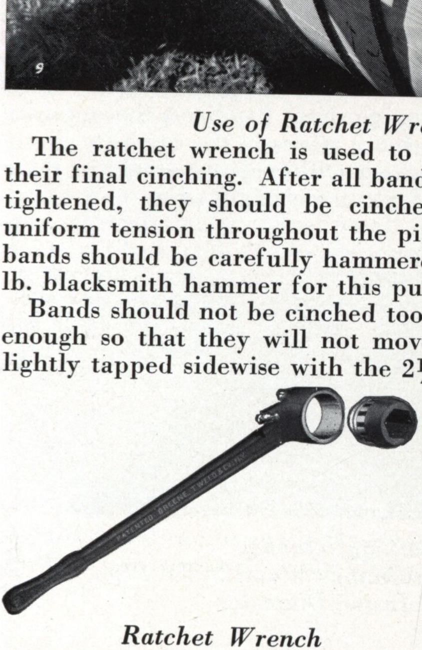
The brace wrench is used to run the nuts down on the thread and give the band its initial tightening.



Use of Ratchet Wrench

The ratchet wrench is used to give the pipe bands their final cinching. After all bands are in position and tightened, they should be cinched again to produce uniform tension throughout the pipe line. All kinks in bands should be carefully hammered out, using the 2½ lb. blacksmith hammer for this purpose.

Bands should not be cinched too tightly—just tightly enough so that they will not move on the stave when lightly tapped sidewise with the 2½ lb. hammer.



Ratchet Wrench

These ratchet wrenches have removable parts that can be replaced when worn out, and heads to fit several sizes of bands can be furnished for one handle.

Crosswind: Crosswind or the twisting of the pipe staves out of their proper alignment is the result of driving up all staves in the same rotation, either clockwise or counter-clockwise, or of giving too many of the bands their initial tightening on one side of the pipe.

To prevent crosswind, the driving of the staves should be alternated; that is, every other stave, selected in a clockwise course around the pipe, should be driven into position. Then the remaining staves, selected counter-clockwise, should be driven up. The first bands should be placed on the pipe so that the shoes are on opposite sides, and they should be given their initial tightening so that tension will be equal on both sides of the pipe.

The staves should remain in their same relative position throughout the length of the pipe line. By observing their alignment, it can easily be seen when the pipe is beginning to twist. This tendency to crosswind can be overcome by tightening more bands on the opposite side or by driving up more staves in the opposite direction from the twist, which will keep the staves in their proper position and result in a straight pipe.

"National Quality"
Creosoted Continuous Wood Stave Pipe
75″ Inside Diameter

Curvature: "National Quality" continuous wood stave pipe can be built to conform to the graceful, natural curvature of the ground without the use of special fittings. The finished curves are not only pleasing in appearance but are very efficient as there are no sharp angles to cause friction loss.

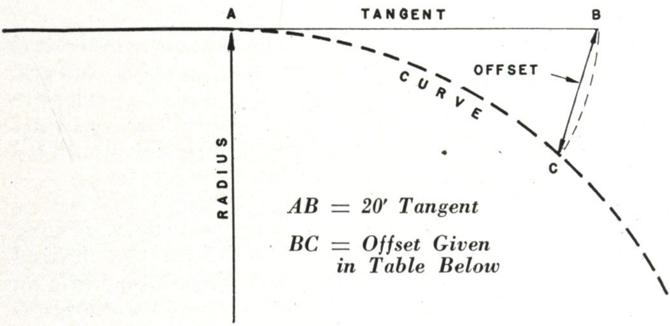
Curvature of continuous stave pipe is usually accomplished by swinging tangent sections into the desired curve. The procedure is as follows: A section built on a tangent and partially tightened with a few bands is swung into the curve. The staves are then driven to assure tight butt joints and the remaining pipe bands placed and cinched.

If the pipe is supported by anchored cradles, the curved sections are built in the cradles. Since the pipe will tend to climb on the out side while it is being built, it is necessary to force the out side down at the same time it is forced over into the cradle.

Small pipe is built into moderate curves by the building crew prying it into position. When large sizes are used on moderate curves or small sizes on sharp curves, jacks or block and tackle are necessary.

As will be readily apparent, the need for sufficient trench width, secure footings, and general field conditions are controlling factors in determining the method of moving the pipe into place.

As a guide for determining what curvature is economically feasible under various field and personnel conditions, the table on page 107 has been prepared. It will be understood that sharper curvatures than those recommended can be made if necessary; however, lower construction costs will result if the suggested radii are followed.



Continuous Wood Stave Pipe Curvature

Tangent Offset Table

Radius	Offset in Inches	Radius	Offset in Inches
60	$39\frac{7}{8}$	275	$8\frac{3}{4}$
70	$34\frac{3}{16}$	300	8
80	$29\frac{15}{16}$	350	$6\frac{7}{8}$
90	$26\frac{5}{8}$	400	6
100	24	450	$5\frac{5}{8}$
110	$21\frac{13}{16}$	500	$4\frac{13}{16}$
120	20	600	4
130	$18\frac{7}{16}$	700	$3\frac{7}{16}$
140	$17\frac{1}{8}$	800	3
150	16	900	$2\frac{11}{16}$
160	15	1000	$2\frac{3}{8}$
170	$14\frac{1}{8}$	1100	$2\frac{3}{16}$
180	$13\frac{5}{16}$	1200	2
190	$12\frac{5}{8}$	1300	$1\frac{7}{8}$
200	12	1400	$1\frac{11}{16}$
225	$10\frac{11}{16}$	1500	$1\frac{5}{8}$
250	$9\frac{5}{8}$	1600	$1\frac{1}{2}$

The information in this table will be found very helpful in analyzing the curvature on which continuous wood stave pipe can be built.

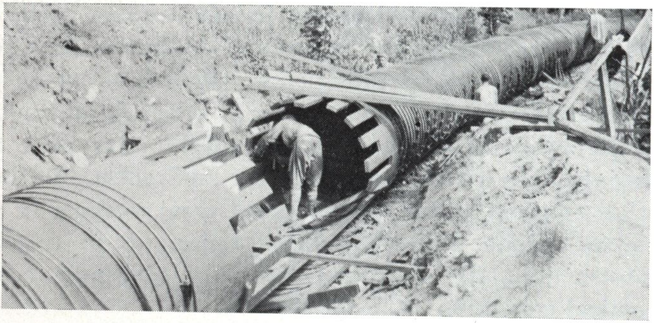
Continuous stave pipe is usually built on a tangent and then swung into its curved position. The "offset in inches" given in the table is the distance that the end of a 20-foot tangent section of pipe would be moved to reach its final position on the curve.

Minimum Curvature: The degree of curvature recommended depends not only upon field conditions, but also on the skill of the operating crew. Conditions are ideal when experienced men can work in a trench of ample width or on a bench where there is solid footing, permitting the free use of jacks or block and tackle. At the other extreme is the inexperienced crew working in a narrow trench, limited working space, or on trestle construction. See following table for minimum economical curvature.

Minimum Economical Curvature

Inside Diameter of Pipe in Feet	Good Conditions	Average Conditions	Poor Conditions
	Radius	Radius	Radius
2	80	115	150
3	120	155	190
4	160	195	230
5	200	240	275
6	240	290	335
7	290	345	400
8	340	420	500
9	400	500	600
10	460	580	700
12	520	660	800
14	590	745	900
16	660	830	1000
18	730	915	1100
20	800	1000	1200

Field conditions and the design of the pipe have a decided bearing on the minimum radius for curves on which continuous wood stave pipe can be built. We shall be pleased to assist you in the design of your project.



"Buckling In" 60″ Diameter "National Quality" Creosoted Douglas Fir Pipe

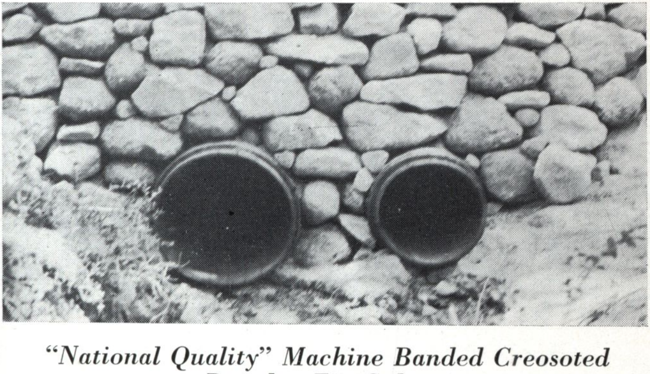
When a pipe line is built from both ends towards the middle, the act of connecting it together is called "buckling in." The picture above shows the crew starting to make the connection. The picture below shows the connection finished and being finally cinched into position with the pipe bands.

"National Quality" Creosoted Douglas Fir Pipe 60″ Diameter

ROAD CULVERTS

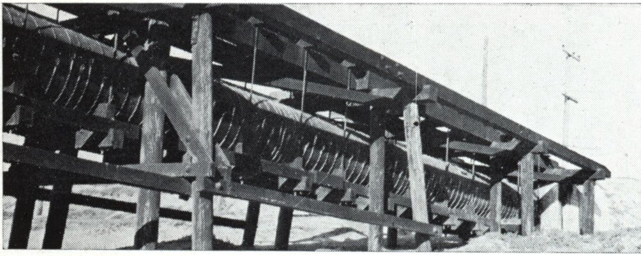
Creosoted Douglas Fir Continuous Stave Culvert

This creosoted Douglas Fir culvert has been in use for over 42 years. It is still in service, in very good condition, and will serve its purpose well for many years to come.



"National Quality" Machine Banded Creosoted Douglas Fir Culvert

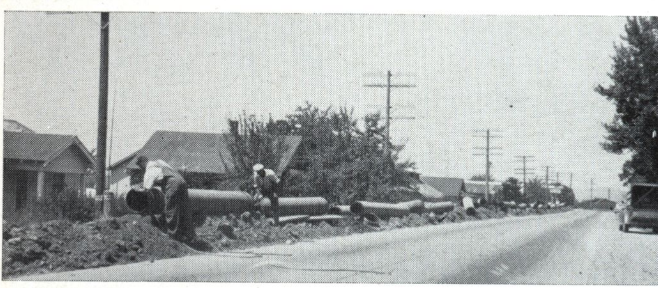
SEWER PIPE



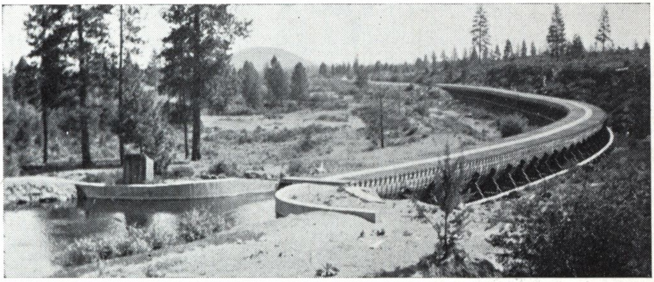
"National Quality"
Creosoted Douglas Fir Sewer Pipe 52″ Inside Diameter

This "National Quality" creosoted Douglas Fir sewer has been in use over 20 years and is still in perfect condition. Creosoted Douglas Fir is the best material obtainable for sewer pipe construction because:

1. It is not affected by acid or sewer gas
2. It will not decay, rust, or tuberculate
3. It is flexible and will not crack
4. It always remains smooth inside and, therefore, has less friction and greater capacity
5. It is easy to install, even under adverse conditions.



"National Quality"
Creosoted Douglas Fir Machine Banded Pipe
16″ Inside Diameter

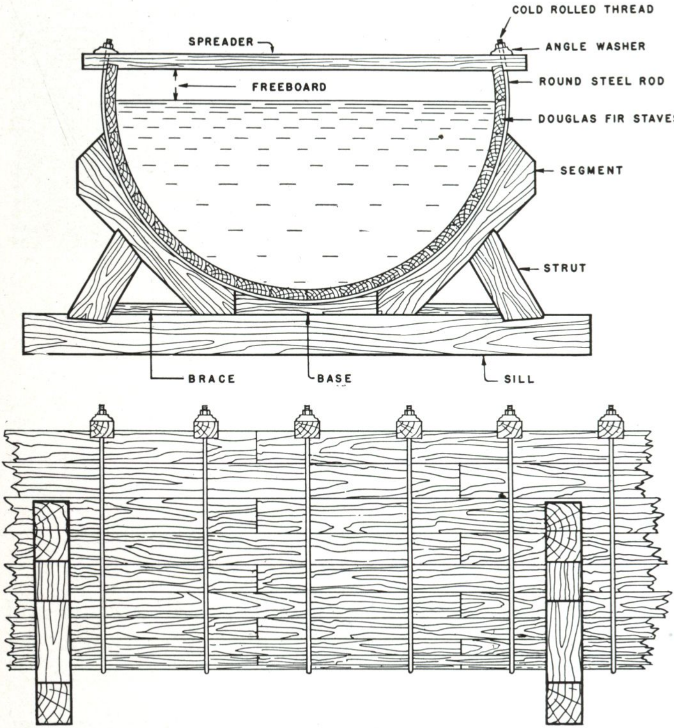


A Typical Semi-circular Wood Stave Flume Installation

WOOD STAVE FLUME

On the following pages you will find illustrated and described "National Quality" semi-circular flume.

"National Quality" Creosoted Douglas Fir Flume 10′ Diameter



"National Quality" Semi-circular Wood Stave Flume

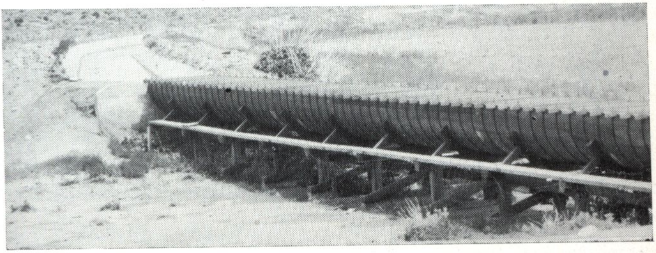
The above illustration shows the general design of "National Quality" semi-circular flume. The capacity of the flume is based on a semi-circle, and that part extending above the semi-circle is allowed for freeboard. This freeboard is equal to one inch for each one foot in diameter.

Table of Sizes and Areas*

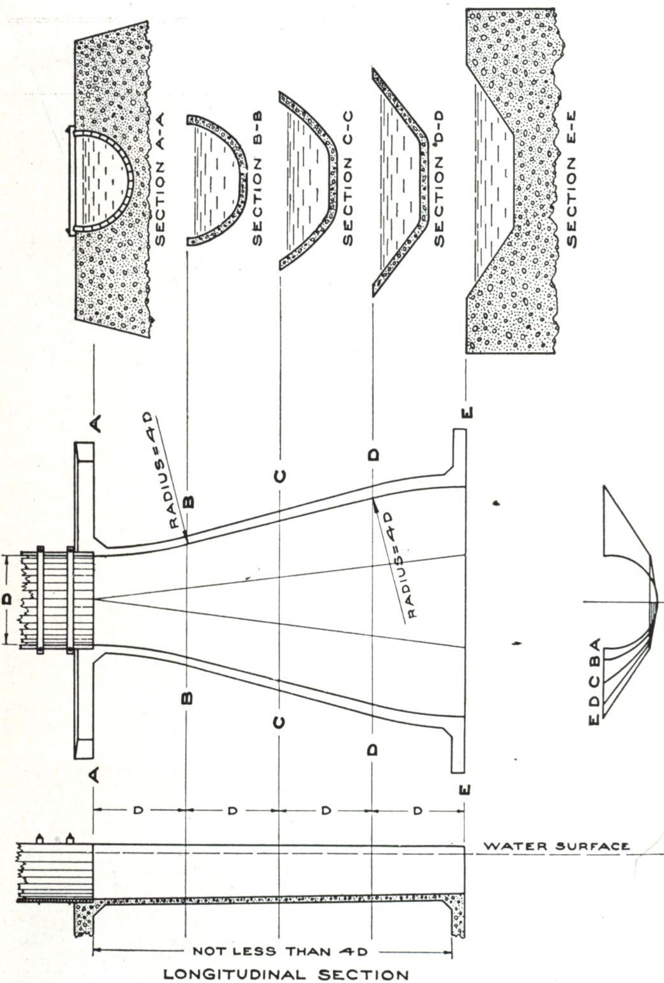
(In Square Feet)

Diameter		Area including Freeboard	Allowance for Freeboard Inches	Area of Semi-Circle
Inches	Feet			
18		1.07	1.50	0.88
20		1.32	1.67	1.09
22		1.60	1.83	1.32
24		1.90	2.00	1.57
26		2.23	2.17	1.84
28		2.59	2.33	2.14
30		2.97	2.50	2.46
36	3	4.28	3	3.54
42	3 ½	5.82	3 ½	4.81
48	4	7.61	4	6.28
54	4 ½	9.62	4 ½	7.95
60	5	11.89	5	9.82
66	5 ½	14.38	5 ½	11.88
72	6	17.11	6	14.14
78	6 ½	20.08	6 ½	16.59
84	7	23.29	7	19.24
90	7 ½	26.74	7 ½	22.09
96	8	30.43	8	25.14
102	8 ½	34.35	8 ½	28.38
108	9	38.51	9	31.81
114	9 ½	42.90	9 ½	35.44
120	10	47.54	10	39.27
132	11	57.52	11	47.52
144	12	68.46	12	56.55
156	13	80.34	13	66.37
168	14	93.18	14	76.97
180	15	106.97	15	88.36
192	16	121.70	16	100.53
204	17	137.39	17	113.49
216	18	154.03	18	127.24
228	19	171.62	19	141.77
240	20	190.16	20	157.08
288	24	273.83	24	226.19

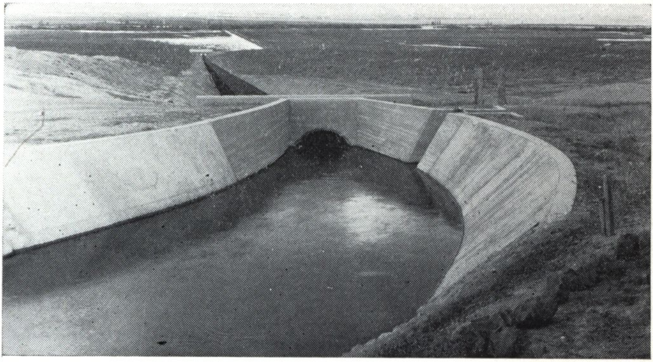
*Flumes are distinguished in size by their inside diameters measured on the radial line.



"National Quality" Douglas Fir Flume



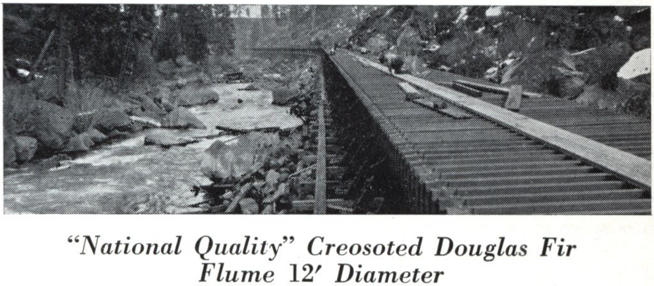
Typical Design of Flume Intake



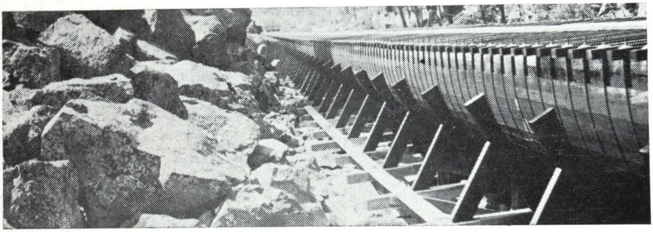
Typical Concrete Discharge Structure For Pipe or Semi-circular Flume

The design of intake and discharge structures should be entrusted to a qualified engineer who is familiar with your field conditions.

The drawing on the opposite page shows a typical design of flume intake which can be readily adapted to any size of flume or ditch. It is the object of this design to reduce as far as possible the loss in head due to the transition from the cross section of the ditch to that of the flume.



"National Quality" Creosoted Douglas Fir Flume 12′ Diameter



"National Quality" Creosoted Douglas Fir Flume 12′ Diameter

Specifications: The staves and bands for "National Quality" flume are manufactured in accordance with the specifications given on page 83 for continuous stave pipe. These specifications can be safely used for all ordinary flume projects. Where special difficulties are encountered, we will be pleased to assist you in drawing up specifications covering your particular requirements.

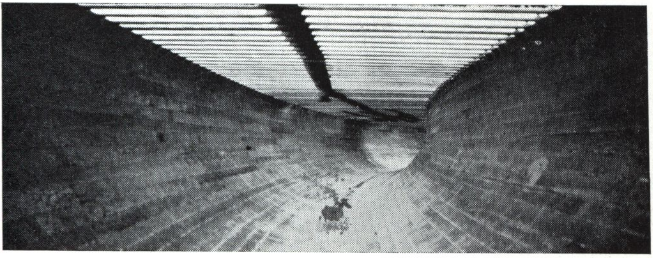
Foundation Cradles: In the continuous stave pipe section of this handbook you will find typical pipe cradle designs. The same type of cradle is used for flume as for continuous stave pipe. We will be pleased to assist you with the design of flume cradles.

Flume Erection: The erection of "National Quality" semi-circular flume is not a difficult job; however, it can be done better and faster by men experienced in this line of work.

We have a large construction organization composed of men who have had many years' experience erecting wood stave pipe and wood stave flume. On large projects we are prepared to contract for the flume erected, ready for use. On small projects it is usually found more economical to have one of our men supervise the work of local labor.

Curvature: "National Quality" semi-circular wood stave flume can be built to conform to the graceful, natural curvature of the ground without the use of special fittings. The finished curves are not only pleasing in appearance but are very efficient as there are no sharp angles to cause friction loss.

The radius of curvatures to which "National Quality" flume can be built is the same as that for continuous stave pipe (see page 107).



View Inside of 12′ Diameter "National Quality" Creosoted Douglas Fir Flume on a Sharp Curve

"National Quality"
70″ Diameter Creosoted Douglas Fir
Continuous Stave Pipe

Pipe in a water works system has value only as it is capable of carrying water. The following facts have made creosoted Douglas Fir pipe preferred for modern installations:

It will not decay, rust, or tuberculate

It is not affected by electrolysis

It is flexible and will not crack

It will carry more water than pipe made of other material

It does not require painting or cleaning

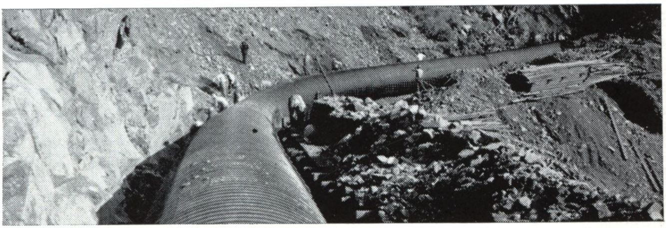
It will last at least 50 years under ordinary conditions without appreciable maintenance costs.

HYDRAULICS

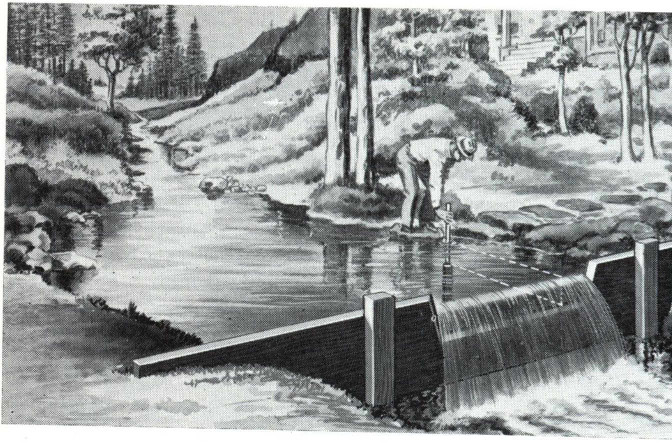
On the following pages will be found a discussion on water measurement, basic hydraulic laws and formulas, and tables giving the complete mathematical solution of formulas covering the flow of water in wood stave pipe and semi-circular flume.

We are deeply indebted to C. A. Mockmore, C.E., Ph.D., M. Am. Soc. C.E., Head of the Department of Hydraulic Engineering, Oregon State College, for his invaluable assistance in the preparation of this hydraulic data.

The information contained in this section will be found very helpful in the study and design of pipe line projects. The design of important projects should be under the direction of qualified engineers who specialize in this type of work.



"National Quality" Creosoted Douglas Fir Pipe



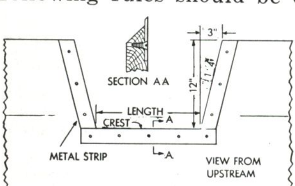
The Cipolletti Weir

MEASUREMENT OF WATER

Measuring Devices: There are numerous kinds of devices for measuring the rate of flow of water, each having its particular accuracy and adaptability. For measuring open channel flow, as for example, the flow in rivers, creeks and irrigation canals, the most common devices in use are weirs and current meters.

Cipolletti Weir: This type of weir is used extensively as it is simple of construction, easy to handle and reasonably accurate.

Care should be taken in the location of the weir and the following rules should be observed as closely as possible:



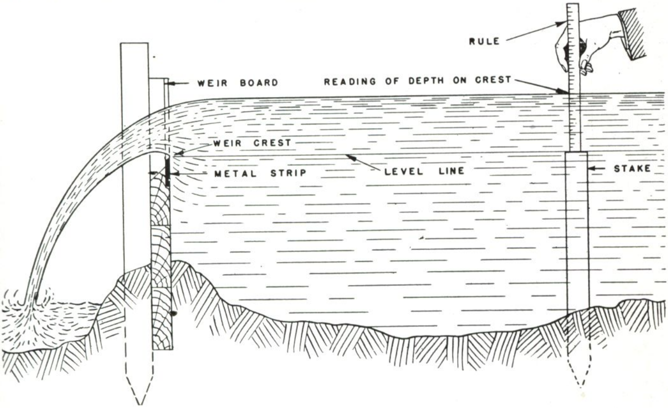
1. The weir should be of such a size as to give a flow of not less than one inch in depth, and the depth of flow should not be greater than one-third of the total length of the weir.

2. The depth of water immediately back of the weir crest should be at least two or three times greater than the maximum depth of water flowing over the weir, and the weir box should be of sufficient width so that the distance from the edges of the weir opening to the

sides of the channel or box be three or more times the maximum depth of water over the weir crest. Observance of these points is required in order to secure full bottom and side contractions.

3. To secure reasonably accurate results, the velocity of approach should not be more than one-half foot per second.

4. The measurement of the depth of water flowing over the weir crest should be made by means of a stake driven



or fastened several feet from the crest in such a manner that its top shall be exactly level with the weir crest. The depth of water on the crest is then ascertained by measuring from the top of the stake to the surface of the water by means of a rule or gauge, as shown above.

5. Weirs when used in ditches should be placed in straight sections of the channel at a point where the area of the channel is sufficiently great to materially reduce the velocity of water to the requirements above mentioned. Where the velocity of approach is too great or the surface of the water is ruffled, excellent results can be obtained by using baffle boards.

6. The weir must be placed high enough so that there will be no obstruction to the overflow. Air should circulate freely beneath the nappe of the overflowing water.

7. The weir should be placed at right angles to the stream, and the crest of the weir must be level.

On the following pages are tables showing the discharge over Cipolletti weirs.

See tables next page

Discharge Over Cipolletti Weir

Discharge in Cubic Feet per Second and Acre Feet per 24 Hours over Cipolletti Weir One Foot in Length
(For Larger Weirs Multiply Values Given by Length in Feet)

Calculations Based on Formula: $Q = 3.367\ LH^{3/2}$

DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours	DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours
½	0.04	0.03	0.06	**6 ¾**	0.56	1.41	2.80
⅝	0.05	0.04	0.08	**6 ⅞**	0.57	1.45	2.88
¾	0.06	0.05	0.10	**7**	0.58	1.49	2.96
⅞	0.07	0.06	0.12	**7 ⅛**	0.59	1.53	3.03
1	0.08	0.08	0.16	**7 ¼**	0.60	1.56	3.09
1 ⅛	0.09	0.09	0.18	**7 ⅜**	0.61	1.60	3.17
1 ¼	0.10	0.11	0.22	**7 ½**	0.62	1.64	3.25
1 ⅜	0.11	0.12	0.24	**7 ⅝**	0.63	1.68	3.33
1 ½	0.12	0.14	0.28	**7 ¾**	0.65	1.76	3.49
1 ⅝	0.14	0.18	0.36	**7 ⅞**	0.66	1.80	3.58
1 ¾	0.15	0.20	0.40	**8**	0.67	1.85	3.67
1 ⅞	0.16	0.22	0.44	**8 ⅛**	0.68	1.89	3.74
2	0.17	0.24	0.48	**8 ¼**	0.69	1.93	3.83
2 ⅛	0.18	0.26	0.52	**8 ⅜**	0.70	1.97	3.91
2 ¼	0.19	0.28	0.55	**8 ½**	0.71	2.01	3.99
2 ⅜	0.20	0.30	0.59	**8 ⅝**	0.72	2.06	4.09
2 ½	0.21	0.32	0.63	**8 ¾**	0.73	2.10	4.17
2 ⅝	0.22	0.35	0.69	**8 ⅞**	0.74	2.14	4.25
2 ¾	0.23	0.37	0.73	**9**	0.75	2.19	4.35
2 ⅞	0.24	0.40	0.79	**9 ⅛**	0.76	2.23	4.43
3	0.25	0.42	0.83	**9 ¼**	0.77	2.27	4.50
3 ⅛	0.26	0.45	0.89	**9 ⅜**	0.78	2.32	4.60
3 ¼	0.27	0.47	0.93	**9 ½**	0.79	2.36	4.68
3 ⅜	0.28	0.50	0.99	**9 ⅝**	0.80	2.41	4.78
3 ½	0.29	0.53	1.05	**9 ¾**	0.81	2.45	4.86
3 ⅝	0.30	0.55	1.09	**9 ⅞**	0.82	2.50	4.96
3 ¾	0.31	0.58	1.15	**10**	0.83	2.55	5.06
3 ⅞	0.32	0.61	1.21	**10 ⅛**	0.84	2.59	5.14
4	0.33	0.64	1.27	**10 ¼**	0.85	2.64	5.24
4 ⅛	0.34	0.67	1.33	**10 ⅜**	0.86	2.69	5.34
4 ¼	0.35	0.70	1.39	**10 ½**	0.87	2.73	5.42
4 ⅜	0.36	0.73	1.45	**10 ⅝**	0.88	2.78	5.52
4 ½	0.37	0.76	1.51	**10 ¾**	0.90	2.88	5.69
4 ⅝	0.39	0.82	1.63	**10 ⅞**	0.91	2.92	5.79
4 ¾	0.40	0.85	1.69	**11**	0.92	2.97	5.89
4 ⅞	0.41	0.88	1.74	**11 ⅛**	0.93	3.02	5.99
5	0.42	0.92	1.82	**11 ¼**	0.94	3.07	6.09
5 ⅛	0.43	0.95	1.88	**11 ⅜**	0.95	3.12	6.19
5 ¼	0.44	0.98	1.94	**11 ½**	0.96	3.17	6.29
5 ⅜	0.45	1.02	2.02	**11 ⅝**	0.97	3.22	6.39
5 ½	0.46	1.05	2.08	**11 ¾**	0.98	3.27	6.49
5 ⅝	0.47	1.08	2.14	**11 ⅞**	0.99	3.32	6.59
5 ¾	0.48	1.12	2.22	**12**	1.00	3.37	6.68
5 ⅞	0.49	1.15	2.28	**12 ⅛**	1.01	3.42	6.78
6	0.50	1.19	2.36	**12 ¼**	1.02	3.47	6.88
6 ⅛	0.51	1.23	2.44	**12 ⅜**	1.03	3.52	6.98
6 ¼	0.52	1.26	2.50	**12 ½**	1.04	3.57	7.08
6 ⅜	0.53	1.30	2.58	**12 ⅝**	1.05	3.62	7.18
6 ½	0.54	1.34	2.66	**12 ¾**	1.06	3.67	7.28
6 ⅝	0.55	1.37	2.71	**12 ⅞**	1.07	3.73	7.40

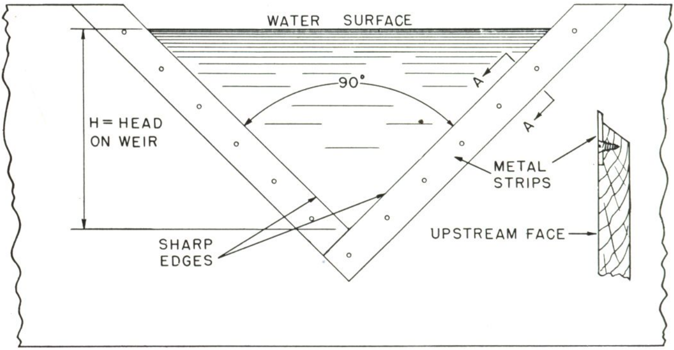
Discharge Over Cipolletti Weir

(Continued)

Discharge in Cubic Feet per Second and Acre Feet per 24 Hours over Cipolletti Weir One Foot in Length
(For Larger Weirs Multiply Values Given by Length in Feet)

Calculations Based on Formula: $Q = 3.367\ LH^{3/2}$

DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours	DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours
13	1.08	3.78	7.50	**19** 3/8	1.61	6.88	13.65
13 1/8	1.09	3.83	7.60	**19** 1/2	1.62	6.94	13.77
13 1/4	1.10	3.88	7.70	**19** 5/8	1.63	7.01	13.90
13 3/8	1.11	3.94	7.82	**19** 3/4	1.65	7.14	14.16
13 1/2	1.12	3.99	7.92	**19** 7/8	1.66	7.20	14.28
13 5/8	1.14	4.10	8.14	**20**	1.67	7.27	14.42
13 3/4	1.15	4.15	8.24	**20** 1/8	1.68	7.33	14.54
13 7/8	1.16	4.21	8.36	**20** 1/4	1.69	7.40	14.68
14	1.17	4.26	8.45	**20** 3/8	1.70	7.46	14.80
14 1/8	1.18	4.32	8.57	**20** 1/2	1.71	7.53	14.93
14 1/4	1.19	4.37	8.67	**20** 5/8	1.72	7.59	15.05
14 3/8	1.20	4.43	8.79	**20** 3/4	1.73	7.66	15.19
14 1/2	1.21	4.48	8.89	**20** 7/8	1.74	7.73	15.33
14 5/8	1.22	4.54	9.01	**21**	1.75	7.79	15.45
14 3/4	1.23	4.59	9.11	**21** 1/8	1.76	7.86	15.59
14 7/8	1.24	4.65	9.23	**21** 1/4	1.77	7.93	15.72
15	1.25	4.70	9.33	**21** 3/8	1.78	8.00	15.86
15 1/8	1.26	4.76	9.44	**21** 1/2	1.79	8.06	15.99
15 1/4	1.27	4.82	9.56	**21** 5/8	1.80	8.13	16.12
15 3/8	1.28	4.88	9.68	**21** 3/4	1.81	8.20	16.26
15 1/2	1.29	4.93	9.78	**21** 7/8	1.82	8.27	16.40
15 5/8	1.30	4.99	9.90	**22**	1.83	8.34	16.54
15 3/4	1.31	5.05	10.02	**22** 1/8	1.84	8.40	16.66
15 7/8	1.32	5.11	10.13	**22** 1/4	1.85	8.47	16.80
16	1.33	5.16	10.24	**22** 3/8	1.86	8.54	16.94
16 1/8	1.34	5.22	10.36	**22** 1/2	1.87	8.61	17.07
16 1/4	1.35	5.28	10.47	**22** 5/8	1.88	8.68	17.21
16 3/8	1.36	5.34	10.60	**22** 3/4	1.90	8.82	17.49
16 1/2	1.37	5.40	10.71	**22** 7/8	1.91	8.89	17.63
16 5/8	1.38	5.46	10.83	**23**	1.92	8.96	17.77
16 3/4	1.39	5.52	10.95	**23** 1/8	1.93	9.03	17.91
16 7/8	1.41	5.64	11.19	**23** 1/4	1.94	9.10	18.05
17	1.42	5.70	11.30	**23** 3/8	1.95	9.17	18.18
17 1/8	1.43	5.76	11.43	**23** 1/2	1.96	9.24	18.32
17 1/4	1.44	5.82	11.55	**23** 5/8	1.97	9.31	18.47
17 3/8	1.45	5.88	11.66	**23** 3/4	1.98	9.38	18.60
17 1/2	1.46	5.94	11.78	**23** 7/8	1.99	9.45	18.74
17 5/8	1.47	6.00	11.90	**24**	2.00	9.52	18.88
17 3/4	1.48	6.06	12.02	**25**	2.08	10.10	20.03
17 7/8	1.49	6.12	12.13	**26**	2.17	10.76	21.35
18	1.50	6.19	12.27	**27**	2.25	11.36	22.53
18 1/8	1.51	6.25	12.39	**28**	2.33	11.98	23.75
18 1/4	1.52	6.31	12.51	**29**	2.42	12.68	25.13
18 3/8	1.53	6.37	12.63	**30**	2.50	13.31	26.40
18 1/2	1.54	6.43	12.75	**31**	2.58	13.95	27.68
18 5/8	1.55	6.50	12.89	**32**	2.67	14.69	29.13
18 3/4	1.56	6.56	13.01	**33**	2.75	15.35	30.48
18 7/8	1.57	6.62	13.13	**34**	2.83	16.03	31.80
19	1.58	6.69	13.27	**35**	2.92	16.80	33.32
19 1/8	1.59	6.75	13.39	**36**	3.00	17.49	34.70
19 1/4	1.60	6.81	13.51				



Triangular Notched Weir

90° Triangular Notched Weir: The 90° V-Notch weir is suited to smaller rates of flow than the Cipolletti weir and gives more accurate results. It can be laid out with a carpenter's square and cut from a wooden bulkhead as illustrated or cut from a steel plate. The same care should be exercised in the placing of this weir as that described for the locating of the Cipolletti weir.

The formula for computing flow of water over this weir is: $Q = 2.536\,H^{\frac{5}{2}}$ where the head, H, in feet is measured from the lowest point in the notch to the level of the water surface. The measurement of the head should be made by means of a stake driven or fastened several feet upstream from the face of the weir in such a manner that its top is exactly level with the lowest point of the notch. The depth of water is then measured from the top of the stake to the surface of the water with a gauge or rule.

For your convenience the following table has been prepared. It indicates the discharge in c.f.s. for given heads on the weir.

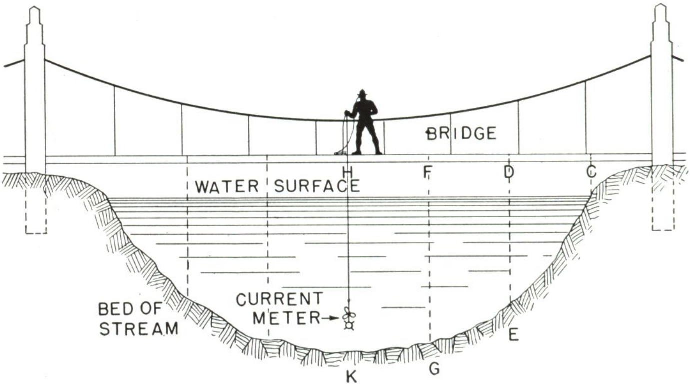
Discharge Over 90° V-Notch Weir

Discharge in Cubic Feet per Second
Over 90-degree V-Notch Weir
Calculations Based on Formula.

$$Q = 2.536\ H^{\frac{5}{2}}$$

Head H in Feet	Cubic Feet per Second	Head H in Feet	Cubic Feet per Second	Head H in Feet	Cubic Feet per Second
.20	.045	.63	.799	1.06	2.934
.21	.051	.64	.831	1.07	3.003
.22	.058	.65	.864	1.08	3.074
.23	.064	.66	.897	1.09	3.146
.24	.072	.67	.931	1.10	3.22
.25	.079	.68	.967	1.11	3.29
.26	.087	.69	1.003	1.12	3.36
.27	.096	.70	1.040	1.13	3.44
.28	.105	.71	1.077	1.14	3.52
.29	.115	.72	1.116	1.15	3.60
.30	.125	.73	1.155	1.16	3.68
.31	.136	.74	1.195	1.17	3.75
.32	.147	.75	1.235	1.18	3.83
.33	.159	.76	1.277	1.19	3.92
.34	.171	.77	1.319	1.20	4.00
.35	.184	.78	1.363	1.21	4.09
.36	.197	.79	1.407	1.22	4.17
.37	.211	.80	1.451	1.23	4.25
.38	.225	.81	1.498	1.24	4.34
.39	.241	.82	1.544	1.25	4.43
.40	.256	.83	1.592	1.26	4.52
.41	.273	.84	1.640	1.27	4.61
.42	.290	.85	1.689	1.28	4.70
.43	.307	.86	1.739	1.29	4.79
.44	.325	.87	1.790	1.30	4.88
.45	.344	.88	1.842	1.31	4.98
.46	.364	.89	1.895	1.32	5.07
.47	.384	.90	1.949	1.33	5.17
.48	.404	.91	2.003	1.34	5.27
.49	.426	.92	2.058	1.35	5.37
.50	.448	.93	2.115	1.36	5.47
.51	.471	.94	2.173	1.37	5.57
.52	.495	.95	2.230	1.38	5.67
.53	.519	.96	2.290	1.39	5.78
.54	.544	.97	2.350	1.40	5.88
.55	.569	.98	2.411	1.41	5.98
.56	.595	.99	2.473	1.42	6.09
.57	.622	1.00	2.536	1.43	6.20
.58	.650	1.01	2.600	1.44	6.31
.59	.678	1.02	2.665	1.45	6.42
.60	.707	1.03	2.731	1.46	6.53
.61	.737	1.04	2.797	1.47	6.64
.62	.767	1.05	2.865	1.48	6.76

See pages 155 to 195 for tables giving the flow of water in wood stave pipe.



Current Meter Gauging Station

Current Meter: In larger streams it is too expensive and often impracticable to construct a weir for measuring the rate of flow. A common practice in such cases is to employ a mechanical device known as a current meter. It consists of a wheel fitted with vanes and mounted on an axis in such a way as to turn freely when placed in the flowing water. To the lower end of the stem piece of the meter is attached a lead weight which steadies it and holds it against the current. The wheel revolves at a rate proportional to the velocity of the current in which it is placed. By rating the meter it is possible to establish a relationship between revolutions per second of the wheel and the velocity of the water in feet per second.

When the meter is immersed in the water, the revolutions of the wheel are counted by means of an electrical contact made at each revolution. The wires of the circuit connected through a battery and ear phones frequently form a means of suspending the meter in the water as shown in the illustration. The meter can be used in conjunction with a boat, cable, or by wading, depending on stream conditions. Many satisfactory gauging stations can be established at bridges.

It should be remembered that the best gauging stations are in fairly straight stretches of channel, free of eddy currents, submerged logs, or large rocks. The velocity of the water should not be unreasonably high or low so that the range of velocities is covered by the rating of the meter. Confluence with other streams or places where the stream overflows its banks should be avoided. To insure a comparatively constant regimen of the stream, the station should be a short distance above a control point or riffle caused by outcrop of bedrock.

Essentially, the current meter method consists in laying out a gauging station as shown, by first establishing a zero point as at C, then marking out at known intervals such as 5, 10, 20 or more feet, depending on the size of the stream, other points as D, F, H, etc., using the bridge to preserve the points. Then the depth of the stream should be sounded, as D — E, and the meter lowered in the water along the line D — E to a depth below D of six-tenths of the total depth. If the stream were 10 feet deep, the meter should be lowered 6 feet below the water surface and a velocity measurement taken. This should then be repeated for the vertical F — G, and an average obtained between these two velocities.

If the velocity for D—E were 3 feet per second and that for F—G were 4 feet per second, the average would be 3.5 feet per second for the area between the two verticals. If F — G were 12 feet and D — E were 10 feet, with a distance of 10 feet between D and F, the area would be $\frac{(12 + 10)}{2} 10 = 110$ square feet. The rate of flow in cubic feet per second between the verticals in question would then be

$$Q = 110 \text{ x } 3.5 = 385 \text{ c.f.s.}$$

This procedure should be repeated for the area between F — G and H — K etc., until the stream has been gauged.

Another method commonly used in measuring the mean velocity in a vertical section such as D — E is known as the 2/10 and 8/10 method.

It consists in lowering the meter to a point 2/10 the depth

of the stream and measuring velocity, then lowering to 8/10 depth and measuring velocity again. The mean velocity in the vertical is assumed to be the arithmetical mean of these two. This method requires more time than the 6/10 method but it is regarded as more accurate.

When accurate measurement of rate of flow with the current meter is desired, care should be taken to be sure that the meter operates according to its rating table. Meters may be rated by the U. S. Bureau of Standards for a reasonable fee or checked by the various current meter manufacturers. Accuracy of the results obtained through the use of these meters should be within 2% to 5% of the true rate of flow, depending upon the care in selection of gauging station and technique in operating the meter.

UNITS OF MEASUREMENT

There are several ways of expressing the rate of flow of water, the most common being cubic feet per second, abbreviated c. f. s. A unit of measurement used to describe the capacity of a pump is the gallon per minute, abbreviated G. P. M. It is equivalent to .00222 c. f. s.

The miner's inch is not a definite unit. It varies as to quantity in the different states. Fifty miner's inches are equivalent to 1 c.f.s. in Idaho, Kansas, Nebraska, New Mexico, North Dakota and South Dakota. In Arizona, California, Montana, and Oregon, 40 miner's inches are equivalent to 1 c.f.s., while in Colorado 38.4 miner's inches are equivalent to 1 c.f.s. Another value is used in British Columbia, where 35.7 miner's inches are equal to 1 c.f.s. Owing to the fact that the miner's inch varies from place to place, the most universally accepted unit of measurement of flowing water is the cubic foot per second.

In irrigation practice the acre foot has been adopted as the unit of measurement where volume is considered independent of time. This is due to the convenience of size and particular application to land areas, the acre foot being equal in volume to one acre covered with water to a depth of one foot, or 43,560 cubic feet of water.

For convenience in converting from cubic feet per second to other units of measurement, the following table has been assembled.

Rate of Flow Conversion Table

Rate of Flow in Cubic Feet per Second Compared to Other Units of Measurement

Cubic Ft. per Second	Gallons per Minute	Thousands of Gallons per 24 Hrs.	Miners Inches		
			50 =1 c.f.s.	40 =1 c.f.s.	38.4=1c.f.s.
0.01	4.49	6.46	0.5	0.4	0.38
0.02	8.98	12.93	1.0	0.8	0.77
0.03	13.46	19.39	1.5	1.2	1.15
0.04	17.95	25.85	2.0	1.6	1.54
0.05	22.44	32.32	2.5	2.0	1.92
0.06	26.93	38.78	3.0	2.4	2.30
0.07	31.42	45.24	3.5	2.8	2.69
0.08	35.90	51.71	4.0	3.2	3.07
0.09	40.39	58.17	4.5	3.6	3.46
0.10	44.88	64.63	5.0	4.0	3.84
0.125	56.10	80.79	6.25	5.0	4.80
0.150	67.32	96.95	7.50	6.0	5.76
0.175	78.54	113.11	8.75	7.0	6.72
0.200	89.76	129.26	10.00	8.0	7.68
0.225	100.98	145.42	11.25	9.0	8.64
0.250	112.20	161.58	12.50	10.0	9.60
0.275	123.42	177.74	13.75	11.0	10.56
0.300	134.64	193.90	15.00	12.0	11.52
0.325	145.86	210.05	16.25	13.0	12.48
0.350	157.08	226.21	17.50	14.0	13.44
0.375	168.30	242.37	18.75	15.0	14.40
0.400	179.52	258.53	20.00	16.0	15.36
0.425	190.74	274.68	21.25	17.0	16.32
0.450	201.96	290.84	22.50	18.0	17.28
0.475	213.18	307.00	23.75	19.0	18.24
0.500	224.40	323.16	25.00	20.0	19.20
0.550	246.84	355.47	27.50	22.0	21.12
0.600	269.28	387.79	30.00	24.0	23.04
0.650	291.72	420.11	32.50	26.0	24.96
0.700	314.16	452.42	35.00	28.0	26.88
0.750	336.60	484.74	37.50	30.0	28.80
0.800	359.04	517.05	40.00	32.0	30.72
0.850	381.48	549.37	42.50	34.0	32.64
0.900	403.92	581.69	45.00	36.0	34.56
0.950	426.36	614.00	47.50	38.0	36.48
1.000	448.80	646.32	50.00	40.0	38.40
1.250	561.00	807.90	62.50	50.0	48.00
1.500	673.20	969.48	75.00	60.0	57.60
1.750	785.40	1131.05	87.50	70.0	67.20
2.000	897.60	1292.63	100.00	80.0	76.80
2.500	1122.00	1615.79	125.00	100.0	96.00
3.000	1346.40	1938.95	150.00	120.0	115.20
3.500	1570.80	2262.11	175.00	140.0	134.40
4.000	1795 20	2585.27	200.00	160.0	153.60
5.000	2244.00	3231.59	250.00	200.0	192.00
6.000	2692.80	3877.90	300.00	240.0	230.40
7.000	3141.60	4524.22	350.00	280.0	268.80
8.000	3590.40	5170.54	400.00	320.0	307.20
9.000	4039.20	5816.85	450.00	360.0	345.60
10.000	4488.00	6463.17	500.00	400.0	384.00

Quantity of Water in One Foot of Pipe

Table Showing Quantity of Water in One Foot of Pipe in Cubic Feet and in U. S. Gallons

Dia. of Pipe in Inches	Cu. Ft. of Water in 1 Ft. of Pipe	U. S. Gals. in 1 Ft. of Pipe	Dia. of Pipe in Inches	Cu. Ft. of Water in 1 Ft. of Pipe	U. S. Gals. in 1 Ft. of Pipe
½	0.0014	0.0105	58	18.348	137.3
¾	0.0031	0.0232	60	19.635	146.9
1	0.0055	0.0411	62	20.966	156.8
2	0.0218	0.1631	64	22.340	167.1
3	0.0491	0.3673	66	23.76	177.7
4	0.0873	0.6531	68	25.22	188.7
5	0.1364	1.020	70	26.73	200.0
6	0.1963	1.469	72	28.27	211.5
8	0.3491	2.612	74	29.87	223.4
10	0.5454	4.080	76	31.50	235.6
12	0.7854	5.875	78	33.18	248.3
14	1.069	7.997	80	34.91	261.2
16	1.396	10.44	82	36.67	274.3
18	1.767	13.22	84	38.48	287.9
20	2.182	16.32	86	40.34	301.8
22	2.640	19.75	88	42.24	316.0
24	3.142	23.50	90	44.18	330.5
26	3.687	27.58	92	46.16	345.3
28	4.276	31.99	94	48.19	360.5
30	4.909	36.72	96	50.27	376.1
32	5.585	41.78	98	52.38	391.8
34	6.305	47.17	100	54.54	408.0
36	7.069	52.88	102	56.75	424.5
38	7.876	58.92	104	58.99	441.3
40	8.727	65.29	106	61.28	458.4
42	9.621	71.97	108	63.62	475.9
44	10.559	78.99	110	66.00	493.7
46	11.541	86.34	112	68.42	511.8
48	12.566	94.01	114	70.88	530.2
50	13.635	102.00	116	73.39	549.0
52	14.748	110.3	118	75.94	568.1
54	15.904	119.0	120	78.54	587.5
56	17.104	128.0			

The cost of wood pipe is so much less than that of other types of standard water pipe that the saving, capitalized, will more than cover all maintenance costs and costs of complete replacement when the pipe has outlived its usefulness.

FLOW OF WATER IN PIPE

The design of important hydraulic structures should be under the direction of qualified engineers who specialize in this type of work. However, it is frequently found desirable for the prospective water user to make an estimate of the approximate size of pipe required to deliver the water or analyze other hydraulic problems. It is for this purpose that the following brief description of hydraulic laws and tabulation of data are assembled.

Basic Hydraulic Laws: Although every stream of water moves in accordance with definite natural laws, such laws are intricate and imperfectly understood. It is for this reason that engineers have taken recourse to experimental methods in applied hydraulics and have, until the past few years, so tenaciously held to the simpler mathematical analyses.

The most elementary treatment of hydraulics should include an analysis of Archimedes' principle, Bernoulli's Theorem, and the law of continuity of flow. Stated mathematically these are:

$$P = WH \quad \text{.......} \quad (1)$$

$$H = Z + \frac{P}{W} + \frac{V^2}{2\,g} + H_f = \text{Constant} \quad \text{.......} \quad (2)$$

$$Q = AV \quad \text{.......} \quad (3)$$

in which P = Pressure in pounds per square foot

W = 62.4 pounds per cubic foot of water

H = Total head, or fall, in feet, measured vertically

Z = Elevation of a point above some arbitrary zero datum plane

V = Velocity of water in feet per second

G = 32.2 = acceleration due to gravity

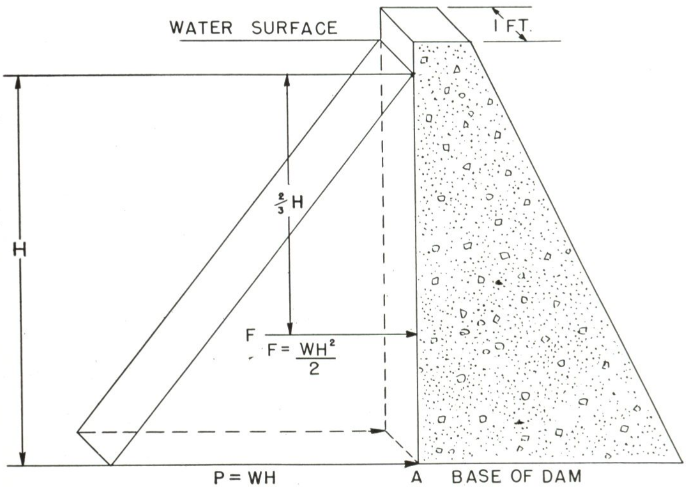
H_f = Loss of head, or fall, due to pipe friction or other losses

Q = Flow of water in cubic feet per second

A = Cross-sectional area of pipe or conduit in square feet

These formulas or mathematical equations serve the same purpose for the hydraulic engineer that the saw, hammer, and the screwdriver serve for the mechanic. They are the working tools.

Hydrostatics: A verification of the Archimedes principle can be given from the basic equation P = W H, or one might say the validity of the equation is based on the Archimedes principle that a body immersed in water is buoyed up by a force equal to the weight of the water displaced. The equation simply states that the intensity of pressure at any point in a body of water is a direct function of the head or the vertical distance from the point to the free water surface.



Water Pressure Against a Dam

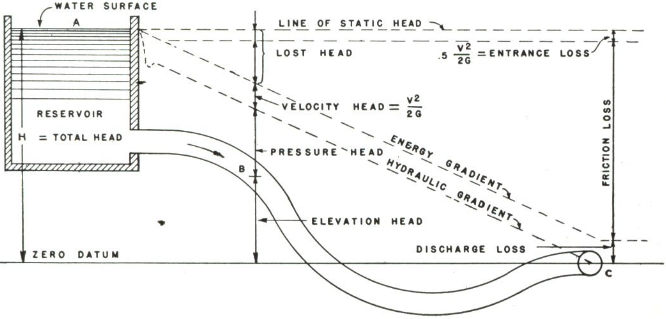
In the illustration the intensity of pressure at the heel of the dam, as at A, is W H pounds per square foot. If the depth of the water is 10 feet, the intensity of pressure is 624 pounds per square foot.

Now, if a section of the dam 1 foot in length be considered, the total horizontal pressure will be

$$F = \frac{W\ H^2}{2} \qquad (4)$$

and may be considered as acting at a point $(\frac{2}{3})$ H below the water surface.

Hydrokinetics: The Bernoulli Theorem is a mathematical statement of the law of conservation of energy as applied to flow of water. In the following illustration is shown water flowing from a reservoir through a pipe line, discharging freely into the air. If a zero datum plane be drawn horizontally through the point C as shown, the total head H or fall causing flow will be the vertical distance from this zero datum plane to the water surface in the reservoir.



As water flows from A to C, it does so by an expenditure of energy. The flow through the pipe is in the direction of the slope of the energy gradient. By the time a particle of water has moved from A to C, all of its energy has been expended, in this case consisting of loss at entrance to the pipe, friction loss in the pipe line, and discharge loss. Thus, writing the Bernoulli equation between the points A and C, there results:

Total Head = Entrance loss + friction loss + discharge loss, or

$$H = .5\ \frac{V^2}{2\,g} + \frac{f\ L\ V^2}{D\ 2\,g} + \frac{V^2}{2\,g} \qquad (5)$$

where: D = Diameter of pipe in feet

f = Pipe friction factor, values of which are given on the following page.

Approximate Values of "f"

in the

Chezy Formula $H_f = f \frac{LV^2}{d2g}$

Pipe Dia. Inches	Straight Smooth New Iron Pipe*			10-yr. Old Cast Iron or Smooth Concrete Pipe*			Old Cast Iron+
	Velocity ft./sec.			Velocity ft./sec.			Vel.
	2′	5′	10′	2′	5′	10′	All
2	.030	.026	.024	.048	.046	.045	.059
3	.029	.025	.023	.044	.042	.041	.054
4	.028	.025	.023	.041	.039	.038	.050
5	.027	.024	.022	.039	.037	.036	.047
6	.026	.024	.022	.037	.035	.034	.045
8	.025	.023	.021	.035	.033	.032	.042
10	.024	.022	.021	.033	.031	.030	.040
12	.023	.021	.020	.031	.030	.029	.038
14	.023	.021	.020	.030	.029	.028	.037
16	.022	.020	.019	.029	.028	.027	.036
18	.021	.020	.019	.028	.027	.026	.034
20	.020	.019	.018	.027	.026	.025	.033
24	.019	.018	.018	.026	.025	.024	.032
30	.018	.017	.017	.025	.024	.023	.030
36	.017	.016	.016	.024	.023	.022	.029
42	.016	.015	.015	.023	.022	.021	.027
48	.015	.014	.014	.022	.021	.020	.026
54	.014	.014	.013	.021	.020	.020	.026
60	.013	.013	.013	.021	.020	.019	.025
72	.012	.012	.012	.019	.019	.019	.024
84	.011	.011	.011	.019	.019	.018	.023
96	.010	.010	.010	.019	.019	.018	.023

These values are for average conditions and were developed after years of research by such eminent authorities as F. C. Lea, E. A. Moritz, H. W. King, J. N. LeConte, and many others.

H = Total Head.
L = Length of Pipe Line.
d = Diameter of Pipe in Feet.
V = Velocity in Feet per Second.
g = Gravity = 32.2.

*Friction loss does not vary exactly as the square of the velocity; hence, friction factor "f" in these cases must be adjusted to specific water velocity.

+ With old cast iron the friction loss varies as the square of the velocity; the value "f" remains the same for all velocities.

The entrance loss of $.5\frac{V^2}{2g}$ is taken as equivalent to the loss of head in flow through a standard short tube, and all the velocity head at discharge is considered as lost. These losses may not be exactly correct for all cases, but they are sufficiently accurate for practical purposes.

When the pipe has a length of approximately 1000 times its diameter, all losses may be considered negligible except the friction loss. In such a case Equation (5) becomes

$$H_f = \frac{f\ L\ V^2}{D\ 2g} \qquad (6)$$

$$\text{or} \quad V = \sqrt{\frac{H_f\ D\ 2\ g}{f\ \ L}}$$

Equation (6) is the Weisbach modification of the Chezy formula in which the friction loss, $\frac{f\ L\ V^2}{D\ 2\ g}$, is equal to the amount of head loss due to the retardation of flow caused by roughness or other factors. Chezy, Fanning, Darcy, and Weisbach experimented with the flow of water in both open and closed short conduits and arrived at the fundamental values for this formula. Many other experimenters have since tabulated values of the variable "f" for various conditions of roughness, velocity, size of pipe, etc.

The original Chezy formula derived in 1775 is written $V = C\sqrt{RS}$ where "C" is also variable and varies with the function of the slope, hydraulic radius, velocity, and other factors representing retarding influences. For years the value of "C" was thought to be a constant; however, later the value was varied as experience dictated.

In 1869 the Chezy formula was modified by Kutter; and, in turn, the Kutter formula was modified by Manning in 1890.

Later Williams and Hazen made a great many experiments on various kinds of pipe and arrived at a new formula which also contains a variable. The Williams-Hazen formula is still used for determining the flow through cast iron and certain other types of pipe.

Later F. C. Scobey, Senior Irrigation Engineer, Bureau of Agricultural Engineering, did a vast amount of experimental work on various types of pipe under actual service conditions and derived a separate formula for the flow of water in each of the following: wood stave pipe, concrete pipe, and riveted and welded steel pipe. His experiments were made quite recently and these formulas are used extensively today in figuring the flow of water through these types of pipe.

If the true powers of the velocity and diameter are obtained for Equation (6), the friction factor becomes a constant. This, precisely, is what was accomplished by F. C. Scobey with specific reference to wood stave pipe after an exhaustive study of many wood pipe installations.

The Scobey formula for wood stave pipe is:

$$H_f = \frac{0.419\ V^{1.8}}{D^{1.17}} \qquad \text{(7)}$$

$$V = 1.62\ D^{0.65}\ H_f^{\ 0.555}$$

$$Q = 1.272\ D^{2.65}\ H_f^{\ 0.555}$$

in which H_f = Loss of head in 1000 feet of pipe.

Formulas (5), (6), and (7) provide the working tools for calculating problems involving the flow of water in iron, concrete, and wood stave pipe. From these formulas it is possible to determine the relative capacities of pipe made from various materials.

Suppose, for example, one wishes to ascertain what quantity of water will be delivered through a 12-inch pipe 1000 feet long with a total head of 10 feet. Assuming the following types of pipe: (1) New or old wood stave pipe; (2) New, smooth cast iron pipe; (3) Ten-year-old cast iron or smooth concrete pipe; (4) Old, tuberculated cast iron pipe.

Using equation (6) because in the above examples the pipe line is 1000 diameters, the following quantities are determined for cast iron and concrete pipe. The values for wood stave pipe are ascertained by using the Scobey formula.

RELATIVE CAPACITIES IN GALLONS PER MINUTE

(1) New or old wood stave pipe	2051
(2) New, smooth cast iron pipe	1953
(3) Ten-year-old cast iron or smooth concrete pipe	1632
(4) Old, tuberculated cast iron pipe	1452

Therefore, it will be seen that wood stave pipe has about 43 per cent greater carrying capacity than old, tuberculated cast iron pipe, 26 per cent more than 10-year-old cast iron pipe or smooth concrete pipe, or 6 per cent more than new, smooth iron pipe.

Wood pipe has a constant carrying capacity regardless of its age. It is always free from scale or tuberculation.

Details of Scobey Formula Computations: Calculations of formula computations, discharge, and velocity values by the use of Scobey's formula are very simple for those who are familiar with logarithms. To obviate tedious calculations the values of $D^{1.17}$ and $V^{1.8}$ have been prepared in table form. As an illustration of the use of these tables, we shall describe the details of determining the velocity and discharge in the case of an 8-inch pipe 1000 feet long, with an assumed fall of 10 feet.

$$\text{Basic Scobey Formula: } H_f = \frac{0.419 \ V^{1.8}}{D^{1.17}}$$

From the following table it will be noted that $D^{1.17}$ for an 8-inch pipe is .6223. Substituting this and $H_f = 10$ feet in the formula, we have:

$$10 = \frac{(0.419) \ V^{1.8}}{.6223}$$

$$\text{Then} \quad V^{1.8} = \frac{(10) \ (.6223)}{.419} = 14.852$$

In the tables showing values for $V^{1.8}$ we find that for $V^{1.8} = 14.852$, the value of V is approximately 4.47 feet per second.

Since $Q = AV$, the quantity of discharge is found by substituting $A = .3491$, the area in square feet of 8-inch pipe, and $V = 4.47$. Then

$$Q = (.3491) \ (4.47) = 1.56 \text{ c.f.s.}$$

Flow Tables: To further simplify calculations involving the Scobey formula, flow tables based on this formula have been prepared which make it possible to obtain solutions directly and without computations (See pages 155 to 195).

As a check on the values determined above, it will be noted in the 8-inch flow table that for a head of 10 feet per 1000 the velocity is 4.47 c.f.s. (third column), and the quantity discharged is 1.56 c.f.s.

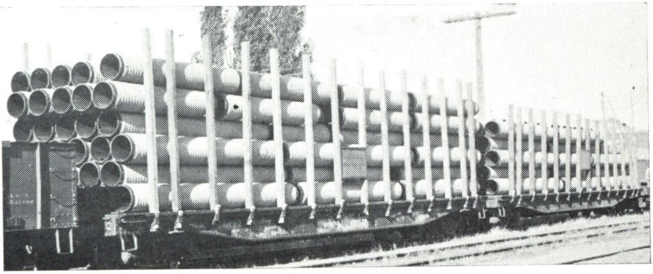
1.17 Powers of Numbers

To facilitate computation of $D^{1.17}$ in the Scobey Formula:

$$H_f = \frac{0.419\ V^{1.8}}{D^{1.17}}$$

Values of Pipe Diameter, D, to 1.17 Powers

d Diameter of Pipe in Inches	D Diameter of Pipe in Feet	$D^{1.17}$	d Diameter of Pipe in Inches	D Diameter of Pipe in Feet	$D^{1.17}$
2	.167	.1229	**50**	4.167	5.311
3	.250	.1975	**52**	4.333	5.560
4	.333	.2765	**54**	4.500	5.811
5	.417	.3591	**56**	4.667	6.064
6	.500	.4444	**58**	4.833	6.318
8	.667	.6223	**60**	5.0	6.574
10	.833	.8079	**66**	5.5	7.349
12	1.000	1.0000	**72**	6.0	8.136
14	1.167	1.198	**78**	6.5	8.935
16	1.333	1.400	**84**	7.0	9.745
18	1.500	1.607	**90**	7.5	10.564
20	1.667	1.818	**96**	8.0	11.392
22	1.833	2.032	**102**	8.5	12.230
24	2.000	2.250	**108**	9.0	13.076
26	2.167	2.471	**114**	9.5	13.930
28	2.333	2.695	**120**	10.0	14.791
30	2.500	2.921	**126**	10.5	15.660
32	2.667	3.151	**132**	11.0	16.536
34	2.833	3.382	**138**	11.5	17.419
36	3.000	3.616	**144**	12.0	18.308
38	3.167	3.852	**150**	12.5	19.204
40	3.333	4.090	**156**	13.0	20.105
42	3.500	4.331	**162**	13.5	21.013
44	3.667	4.573	**168**	14.0	21.926
46	3.833	4.817	**174**	14.5	22.845
48	4.000	5.063	**180**	15.0	23.770



"National Quality" Machine Banded Wood Stave Pipe

1.8 Powers of Numbers

To facilitate computation of $V^{1.8}$ in the Scobey Formula:

$$H_f = \frac{0.419\ V^{1.8}}{D^{1.17}}$$

No.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.5	.2872	.2976	.3082	.3189	.3298	.3409	.3522	.3636	.3751	.3868
.6	.3987	.4106	.4230	.4353	.4478	.4605	.4733	.4863	.4995	.5128
.7	.5262	.5398	.5536	.5675	.5816	.5958	.6102	.6247	.6394	.6542
.8	.6692	.6843	.6996	.7151	.7306	.7464	.7622	.7783	.7945	.8108
.9	.8273	.8439	.8606	.8775	.8946	.9118	.9292	.9467	.9643	.9820
1.0	1.000	1.018	1.036	1.055	1.073	1.092	1.111	1.129	1.149	1.168
1.1	1.187	1.207	1.226	1.246	1.266	1.286	1.306	1.327	1.347	1.368
1.2	1.388	1.409	1.430	1.452	1.473	1.494	1.516	1.538	1.560	1.582
1.3	1.603	1.626	1.648	1.675	1.694	1.716	1.739	1.762	1.786	1.809
1.4	1.832	1.856	1.880	1.904	1.928	1.952	1.976	2.001	2.025	2.050
1.5	2.075	2.100	2.125	2.150	2.175	2.201	2.226	2.252	2.278	2.304
1.6	2.330	2.357	2.383	2.410	2.436	2.463	2.490	2.517	2.544	2.572
1.7	2.599	2.627	2.654	2.682	2.710	2.738	2.766	2.795	2.823	2.851
1.8	2.881	2.910	2.939	2.968	2.997	3.026	3.056	3.085	3.115	3.145
1.9	3.175	3.205	3.236	3.266	3.297	3.327	3.358	3.389	3.420	3.451
2.0	3.482	3.514	3.545	3.577	3.609	3.640	3.673	3.705	3.737	3.769
2.1	3.802	3.835	3.867	3.900	3.933	3.966	4.000	4.033	4.067	4.100
2.2	4.134	4.168	4.202	4.236	4.270	4.305	4.339	4.374	4.408	4.443
2.3	4.478	4.513	4.549	4.584	4.620	4.655	4.691	4.727	4.763	4.799
2.4	4.835	4.871	4.908	4.944	4.981	5.018	5.055	5.092	5.129	5.166
2.5	5.203	5.241	5.279	5.316	5.354	5.392	5.430	5.469	5.507	5.546
2.6	5.584	5.623	5.662	5.701	5.740	5.779	5.818	5.858	5.897	5.937
2.7	5.977	6.017	6.057	6.097	6.137	6.177	6.218	6.258	6.299	6.340
2.8	6.381	6.422	6.463	6.505	6.546	6.587	6.629	6.671	6.713	6.755
2.9	6.797	6.839	6.882	6.924	6.967	7.009	7.052	7.095	7.138	7.181
3.0	7.225	7.268	7.312	7.355	7.399	7.443	7.487	7.531	7.575	7.620
3.1	7.664	7.709	7.753	7.798	7.843	7.888	7.933	7.978	8.024	8.069
3.2	8.115	8.160	8.206	8.252	8.298	8.344	8.391	8.437	8.483	8.530
3.3	8.577	8.624	8.671	8.718	8.765	8.812	8.860	8.907	8.955	9.002
3.4	9.050	9.098	9.147	9 194	9.243	9.291	9.340	9.388	9.437	9.486
3.5	9.535	9.584	9.633	9.682	9.732	9.782	9.831	9.881	9.931	9.981
3.6	10.030	10.081	10.132	10.182	10.233	10.283	10.334	10.385	10.436	10.487
3.7	10.544	10.589	10.641	10.692	10.744	10.796	10.848	10.900	10.952	11.004
3.8	11.056	11.109	11.161	11.214	11.267	11.319	11.372	11.426	11.479	11.532
3.9	11.584	11.639	11.693	11.746	11.800	11.854	11.908	11.962	12.017	12.071
4.0	12.126	12.180	12.235	12.290	12.345	12.400	12.455	12.510	12.566	12.621
4.1	12.676	12.732	12.788	12.844	12.900	12.956	13.013	13.069	13.125	13.182
4.2	13.239	13.295	13.353	13.409	13.467	13.524	13.581	13.639	13.696	13.754
4.3	13.812	13.869	13.928	13.985	14.044	14.102	14.160	14.219	14.278	14.336
4.4	14.395	14.454	14.513	14.572	14.631	14.691	14.750	14.810	14.870	14.929
4.5	14.989	15.049	15.109	15.170	15.230	15.290	15.351	15.412	15.472	15.533

"National Quality" wood stave pipe will deliver water year after year for less money than pipe made of any other material.

1.8 Powers of Numbers

To facilitate computation of $V^{1.8}$ in the Scobey Formula:

$$H_f = \frac{0.419\ V^{1.8}}{D^{1.17}}$$

No.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
4.6	15.594	15.655	15.716	15.778	15.839	15.900	15.962	16.024	16.086	16.148
4.7	16.210	16.272	16.334	16.396	16.459	16.521	16.584	16.647	16.710	16.773
4.8	16.836	16.899	16.923	17.025	17.089	17.153	17.216	17.280	17.344	17.408
4.9	17.472	17.536	17.601	17.665	17.730	17.795	17.859	17.924	17.989	18.054
5.0	18.120	18.185	18.250	18.316	18.381	18.447	18.513	18.578	18.645	18.711
5.1	18.777	18.843	18.910	18.976	19.043	19.110	19.176	19.243	19.310	19.378
5.2	19.445	19.512	19.580	19.647	19.715	19.783	19.851	19.919	19.987	20.055
5.3	20.123	20.192	20.260	20.329	20.397	20.466	20.535	20.604	20.673	20.742
5.4	20.811	20.881	20.951	21.020	21.090	21.160	21.230	21.300	21.370	21.440
5.5	21.510	21.581	21.652	21.722	21.793	21.864	21.935	22.006	22.077	22.148
5.6	22.220	22.291	22.363	22.434	22.506	22.578	22.650	22.722	22.794	22.867
5.7	22.939	23.011	23.084	23.157	23.230	23.303	23.375	23.448	23.522	23.595
5.8	23.668	23.742	23.816	23.889	23.963	24.037	24.111	24.185	24.259	24.334
5.9	24.408	24.482	24.557	24.632	24.707	24.782	24.857	24.932	25.007	25.082
6.0	25.158	25.233	25.309	25.385	25.460	25.536	25.612	25.689	25.765	25.841
6.1	25.918	25.994	26.071	26.147	26.224	26.301	26.378	26.455	26.533	26.610
6.2	26.687	26.765	26.843	26.920	26.998	27.076	27.154	27.232	27.310	27.389
6.3	27.467	27.546	27.624	27.703	27.782	27.861	27.940	28.019	28.098	28.177
6.4	28.257	28.336	28.416	28.496	28.576	28.656	28.736	28.816	28.896	28.976
6.5	29.057	29.137	29.218	29.298	29.379	29.460	29.541	29.622	29.703	29.785
6.6	29.866	29.948	30.029	30.111	30.193	30.275	30.357	30.439	30.521	30.603
6.7	30.686	30.768	30.851	30.933	31.016	31.099	31.182	31.265	31.348	31.431
6.8	31.515	31.598	31.682	31.766	31.849	31.933	32.017	32.101	32.185	32.270
6.9	32.354	32.438	32.523	32.608	32.692	32.777	32.862	32.947	33.032	33.118

No.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
7	33.203	34.062	34.930	35.808	36.696	37.593	38.500	39.417	40.343	41.279
8	42.224	43.179	44.143	45.117	46.100	47.093	48.095	49.106	50.127	51.157
9	52.196	53.244	54.302	55.369	56.446	57.531	58.626	59.730	60.842	61.965
10	63.096	64.236	65.385	66.544	66.711	68.888	70.073	71.267	72.471	73.683
11	74.904	76.135	77.374	78.622	79.878	81.144	82.418	83.702	84.994	86.295
12	87.605	88.923	90.250	91.586	92.931	94.284	95.646	97.017	98.396	99.784
13	101.18	102.59	104.00	105.42	106.85	108.29	109.74	111.20	112.66	114.14
14	115.62	117.11	118.61	120.12	121.63	123.16	124.69	126.23	127.78	129.34
15	130.91	132.48	134.07	135.66	137.27	138.87	140.48	142.11	143.74	145.38
16	147.03	148.69	150.36	152.03	153.71	155.41	157.11	158.81	160.53	162.25
17	163.99	165.73	167.48	169.23	171.00	172.77	174.55	176.34	178.14	179.94
18	181.76	183.58	185.41	187.25	189.09	190.94	192.81	194.68	196.55	198.44
19	200.33	202.24	204.15	206.06	207.99	209.92	211.87	213.82	215.77	217.74
20	219.71	221.69	223.68	225.68	227.69	229.70	231.72	233.75	235.78	237.83

A complete mathematical solution of the Scobey formula will be found in tables on pages 155 to 195. These tables give the friction losses and discharge for each size of pipe.

An excerpt from the 12″ Wood Pipe Flow Table is shown below. The complete table will be found on page 162.

Flow of Water in Wood Stave Pipe

Diameter 12 Inches
Area 0.7854 Sq. Ft.   (1 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
10.0	0.79	5.82	**4.57**	2050	9.06
12.0	0.97	6.43	**5.05**	2270	10.00
14.0	1.2	7.01	**5.51**	2470	10.9
16.0	1.3	7.55	**5.93**	2660	11.8
18.0	1.5	8.06	**6.33**	2840	12.6
20.0	1.7	8.54	**6.70**	3010	13.3
22.0	1.9	9.01	**7.08**	3180	14.0
24.0	2.1	9.45	**7.43**	3330	14.7

The flow tables are the result of a complete mathematical solution of the following formula derived by F. C. Scobey, Senior Irrigation Engineer Bureau of Agricultural Engineering.

$$H_f = \frac{0.419 \ V^{1.8}}{D^{1.17}}$$

in which

H_f = Head in feet required for friction in 1000 feet of pipe

D = Inside diameter of pipe in feet

V = Velocity in feet per second

The complete derivation of this formula will be found in Bulletin No. 376 of the United States Department of Agriculture dated November 25, 1916, revised October, 1925.

The discharge in cubic feet per second, gallons per minute, or acre feet per 24 hours as well as the velocity, friction loss, and velocity and entrance head losses can be found from these tables without tedious calculations.

These flow tables are very conservative as the Scobey formula was derived after numerous tests on pipe lines

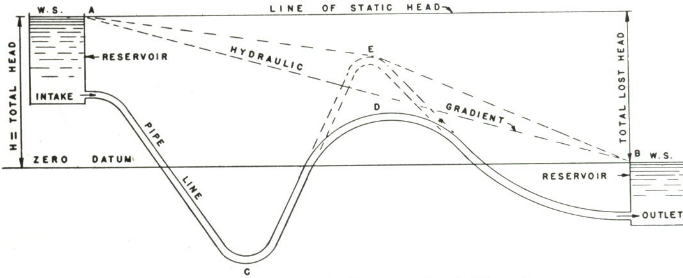
operating under various actual working conditions. The influence of gentle curves was included in the data upon which the formula was based; therefore, an additional friction loss for ordinary curvature need not be considered in the design of wood stave pipe lines.

Referring to the table on the opposite page, in the first column will be found head in feet required for friction in 1000 feet of pipe necessary to deliver the quantity of water shown under the heading "Discharge" in cubic feet per second, gallons per minute, or acre feet per 24 hours. In the third column will be found the velocity in feet per second.

When water flows from a reservoir into a pipe line, it meets with resistances, due to friction, contraction, etc., that absorb part of its energy. This causes a loss of head similar to the loss when water flows through an orifice or a short tube. Such resistances are called loss of head at entrance or entrance head. A certain amount of head is also required to accelerate the flow of water to develop the required velocity in the pipe, which is called velocity head. In the second column of the table will be found the combined amount of velocity and entrance head in feet. This is the depth of water which should stand over the top of the pipe at the intake to provide for entrance and velocity losses. The entrance loss may be reduced somewhat by enlarging the pipe at the intake.

The velocity and entrance head may be disregarded without serious error in determining the flow of water in long pipe lines. Where the length is more than 1000 times the diameter of the pipe and the velocity is low, this velocity and entrance head becomes insignificant and can be disregarded; however, on short pipe lines, it becomes an important factor and should be taken into consideration in determining the head available for friction loss for the required discharge.

On the following pages will be found the solution of several typical hydraulic problems by use of these flow tables.



Profile of Line with Open End Discharge

In the above illustration is shown a long pipe line between two reservoirs. The hydraulic gradient in this case can be considered as a straight line connecting the water surface at the intake with the water surface at the outlet.

In the construction of a pipe line, care should be taken to avoid laying the pipe above the hydraulic gradient as at "E," in which case the hydraulic gradient would run from "A" to "E" and then to "B" as shown by the dotted line, which would reduce the slope of the hydraulic gradient from "A" to "E" and consequently reduce the discharge.

Combination air and vacuum valves should be placed at all summits, such as at "D," to release air which is drawn in with the water at the intake and collects at the high points along the line. It is very difficult to keep air out of a pipe line; and if means for its removal are not provided, it is possible a sufficient amount will accumulate to seriously interfere with the flow of water.

These valves are also designed to let air into the pipe at the summits where a vacuum would be developed by the sudden opening of valves along the line, because the water would be drawn off more rapidly than supplied.

Blow offs or clean out valves should be placed at all low points in the line, as at "C," to allow for draining the pipe and also to remove any debris which may accumulate and interfere with the flow of water.

How to use the flow tables to determine the capacity or the size of pipe illustrated on the opposite page:

Problem: Find discharge in cubic feet per second.

Known:	Length of pipe	20,000′
	Diameter of pipe	12″
	Total Head—H	200′

The first thing we must do is to find out how much head we have available to overcome friction in the pipe line. We assume that there is no valve or other obstruction at the outlet and that all the water is allowed to flow freely into the lower reservoir. As this is a long line, the entrance and velocity head can be disregarded without appreciable error and all of the 200′ head considered available for overcoming friction. To find the head available for each 1000 feet of pipe, we divide the total head available for friction by the length of the pipe in thousands of feet; that is, by the number of thousands of feet of pipe in the line, or 200 divided by 20 (thousands) gives us 10 feet of head available to overcome friction in each 1000 feet of pipe.

Now, to find out how much water will flow through this pipe line, we simply refer to the wood pipe flow table for 12″ pipe on page 162 where the answer is completely worked out. In the first column we find 10′ head and directly opposite this figure in the fourth column we find 4.57, which is the discharge in cubic feet per second.

Problem: Find size of pipe.

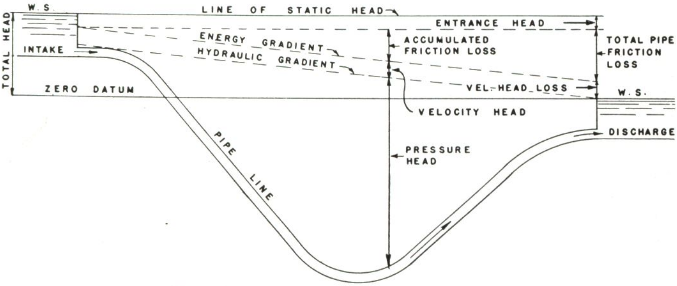
Known:	Required discharge in cubic feet per second	9.0
	Length of pipe	20,000′
	Total Head—H	200′

As in the previous problem, it is first necessary to find the number of feet of head available for friction in each

1000 feet of pipe, which again would be 10 feet. We now search through the flow tables looking in column 4 for a figure that approximates 9.0 cubic feet per second, having opposite it in the first column 10 feet for friction head loss. For example, suppose we first turn to the flow table for 18″ pipe, and in column 4 we look for the discharge 9.0. The nearest we can find is 9.1 and opposite this in the first column 5 feet. We immediately see that this pipe is too large as we have 10 feet instead of 5 feet of head available for friction loss, and if the 10 feet were used, this 18″ pipe would discharge 13.4 cubic feet per second.

Next, we investigate in the same way flow tables for a smaller size of pipe. In the table for 16″ pipe we find in the fourth column 9.23, and opposite in the first column we find 9 feet. This is very close to the required quantity and head; however, we will now look in the flow table for 14″ pipe. Here we find 9.53, which approximates the 9 cubic feet per second; but in the first column the friction loss is 18 feet, which is very much more head than we have available. It is now evident that the 16″ pipe more nearly meets the requirements; and we find that opposite a head loss of 10 feet per thousand feet in the first column, the pipe will actually discharge 9.8 cubic feet per second, which is close enough to the required discharge for all practical purposes.

The standard sizes of pipe vary in diameter by 2-inch increments; for example, 14″, 16″ and 18″ inside diameter. There is a wide variance in the amount of water carried through pipes of the different sizes. For instance, under the conditions outlined in the above problem, 14″ pipe would carry 6.87 c.f.s., 16″ pipe 9.8 c.f.s., and 18″ pipe 13.4 c.f.s. Therefore, it will be seen that the approximate answer is close enough for all practical purposes. In the final analysis the standard size of pipe that most nearly meets the requirements will be used, but if the desired discharge were half way between two sizes of pipe, only an economic analysis would dictate the size of pipe to use.



Profile of Inverted Siphon
(Sag Pipe)

How to use the flow tables to determine the size or capacity of the pipe line illustrated above:

Problem: Find the discharge in cubic feet per second.

Known:	Total length of pipe	3000′
	Diameter of pipe	72″
	Total Head—H	3′

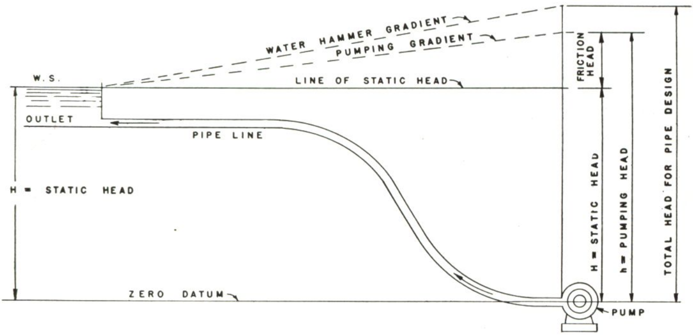
The first thing we must do is to find how much head we have available to overcome friction in the pipe line. We assume that there are no obstructions at the outlet. As this is a short line compared to its diameter, it is necessary to take into consideration the velocity and entrance head. Therefore, all of this 3-foot head cannot be considered available for overcoming friction, as the velocity and entrance head losses must first be deducted. To obtain the amount of velocity and entrance head, we must first find the amount of total head which we have per thousand feet of pipe. This is obtained by dividing the total head, which is 3 feet, by 3 (thousands) which gives us 1-foot head per thousand feet of pipe. We now turn to the flow table for 72″ pipe and in the first column we find 1.0 feet. Opposite this in the second column we find 0.63 feet, which is the total amount of velocity and entrance head which must be deducted from the total head of 3 feet, leaving 2.37 feet available to overcome friction in the pipe line. Now, to find the amount

of head available for overcoming the friction in each 1000 feet of pipe, we divide 2.37 by 3 (thousands), which gives us 0.79 feet to overcome the friction in each 1000 feet of pipe. Again turning to the flow tables for 72″ pipe, we look for 0.79 in column 1 and find .8 feet, which is close enough for practical purposes. Opposite this in column 4 we find that the quantity of water delivered through the pipe would be 130 cubic feet per second. If the entrance and velocity head losses had been disregarded in this case and the total head of 3 feet considered as being available, then the head for friction loss in each 1000 feet of pipe would have been 1 foot and the discharge would have appeared to be 147 cubic feet, which would have involved an error of about 13 per cent.

Problem: Find size of pipe required.

Known:	Required discharge in cubic feet per second	190
	Length of pipe line	3000′
	Total head—H	3′

As in the previous problem, it is first necessary to find the number of feet of head available for each 1000 feet of pipe, which again would be 1 foot. Now, we search through the flow tables looking in column 4 for a figure approximating 190 cubic feet per second and having opposite it in the first column 1 foot or slightly less. For example, suppose we turn to the flow tables for an 84″ pipe. In the fourth column we find 195, opposite it in the first column 0.8 feet, and next to this in the second column 0.6 which is total amount of velocity and entrance head. This velocity and entrance head loss must be deducted from the total head of 3 feet, leaving 2.4 feet to overcome friction in 1000 feet of pipe. We divide this velocity of 2.4 by 3 (thousands), giving us 0.8 feet which is the adjusted friction head for each 1000 feet of pipe. Again referring to the flow tables for 84″ pipe, we find 0.8 feet in the first column, and directly opposite this in the fourth column we find 195 cubic feet per second, which is the discharge of the pipe line and is close enough to the required amount for all practical purposes.



Profile of Pump Line

How to determine the horse power required to pump a given amount of water through the pipe line illustrated above:

Problem: Find required horse power.

Known:	Length of pipe	2000′
	Diameter of pipe	24″
	Static head—H	100′
	*Discharge—Q	16 c.f.s.
	Pump efficiency	80%

In all pumping problems it may be assumed that the required amount of water is lifted straight up above the pump to such a height that it will flow by gravity to the point of discharge. In this problem we know that the pipe line is 24″ diameter and that the required discharge is 16 c.f.s.; therefore, we refer to the flow table for 24″ pipe, and in the fourth column we look for 16, and opposite this in column 1 we find 3.5, which is the head required to overcome friction in each 1000 feet of 24″ pipe when discharging 16 c.f.s. The pipe line is 2000 feet long; therefore, the total friction head would be two times 3.5 or 7 feet. This

*To convert cubic feet per second (c.f.s.) to gallons per minute (G.P.M.) multiply c.f.s. by 448.8.

7 feet of friction head is added to the 100 feet of static head, which gives us a total pumping head of 107 feet.

The theoretical horse power to operate the pump would be

$$\text{Pump horse power} = \frac{Qh}{8.8}$$

$$= \frac{16 \times 107}{8.8} = 195 \text{ h.p.}$$

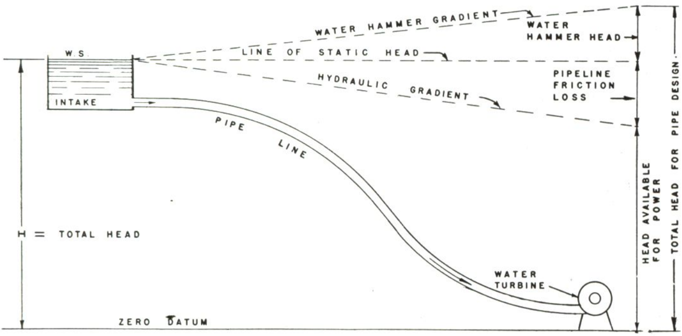
Pumping equipment is not 100% efficient; therefore, more than the theoretical horse power will be required. Assuming that the pump efficiency is 80%, the required horse power would be

$$\text{Pump input horse power} = \frac{195}{.80} = 244 \text{ h.p.}$$

If the pipe line under consideration is short compared to its diameter, the velocity head, which is two-thirds of the velocity and entrance head shown in column 2 of the flow tables, should be taken into consideration and added to the pumping head.

In the above illustration you will note there is a water hammer gradient extending from the water surface of the reservoir to a point directly above the pump. This gradient denotes the working head for which the pipe must be designed and is not taken into consideration in determining the horsepower. The amount of this water hammer varies with the type of pump equipment and operating conditions.

In the above problem if an 18″ pipe had been used instead of the 24″ pipe, there would have been 291 horse power required. On the other hand, if a 30″ pipe had been used, only 233 horse power would have been required. Thus, it will be seen that it is advisable to determine the horse power required to pump the water through several different sizes of pipe and also the costs of pipe, pump, and power. Such an analysis would dictate the most economical size of pipe to be used.



Profile of Power Line

How to use the flow tables to determine the size of pipe and the power which can be developed in the power project illustrated above:

Problem: Find the amount of power.

Known:	Length of pipe line	5000′
	Total head—H	200′
	Quantity of water—Q	10 c.f.s.
	Turbine efficiency—E	85%

Power is developed in proportion to the net effective total head. Now, in order to find the amount of this head that is available for the generation of power, we must first find the amount of head that will be lost in overcoming friction in the pipe line, which amount will vary with the size of pipe. Let us take, for instance, a 14″ diameter pipe. We look in the flow table for 14″ pipe and in the fourth column for 10 c.f.s., which is the amount of water we have available. We find 10.1, which is the nearest figure, and opposite this in the first column we find 20′, which is the amount of head required to overcome friction in each 1000′ of pipe. As the pipe line is 5000′ long, the total friction head would be 100′. This deducted from the 200′ total

head would leave 100′ head available for the generation of power. The total theoretical horse power would then be

$$\text{Theoretical horse power} = \frac{Qh}{8.8} = \frac{(10)\ (100)}{8.8} = 113 \text{ H.P.}$$

This is the amount of power that would be developed if the turbine were 100% efficient, but as the turbine considered here is only 85% efficient, the power output of the turbine would be

$$\text{Turbine horse power} = \frac{QhE}{8.8} = \frac{(10)\ (100)\ (.85)}{8.8} = 96 \text{ H. P.}$$

Now, if this is not enough power to take care of our requirements, it will be necessary to use a larger pipe. We would then investigate, for instance, 18″ diameter pipe.

By referring to the flow table for 18″ pipe, we find that the friction loss per 1000′ of pipe would be 6′; and as the pipe line is 5000′ long, the total friction loss would be 30′. This amount deducted from the total head of 200′ would leave us 170′ for operating the power turbine. Then, the available horse power would be

$$\frac{QhE}{8.8} = \frac{(10)\ (170)\ (.85)}{8.8} = 164 \text{ H. P.}$$

It will be seen from the above that it is advisable to investigate several sizes of pipe and, in the final analysis, the cost of the pipe line, generating equipment, etc., and the required amount of power and its value will dictate the size of pipe to be used.

In this problem we have neglected the velocity and entrance head as this is a long pipe line. If the pipe had been short compared to its diameter, the velocity and entrance head given in the second column of the flow tables would have been deducted from the total head which would give more accurate results.

The amount of water hammer head varies with the type of equipment used and operating conditions and should be added to the static head in determining the head for which the pipe is designed. It is sometimes found possible to install a standpipe or other equipment to relieve the pipe line of this water hammer pressure.

How to use the flow tables to determine the capacity of a pipe line consisting of two different sizes of pipe:

Problem: Find discharge in cubic feet per second.

Known:	Size of pipe	8″ and 10″
	Length of 8″ pipe	5,000′
	Length of 10″ pipe	5,000′
	Total Head	48′

Assuming this pipe line has an open end discharge, we know that the total head of 48′ is available to overcome friction and that the friction head of the 8″ pipe plus the friction head used in the 10″ pipe will equal this total head. We also know that as a certain amount of water will flow through the line, the same amount must flow through each of the two sizes of pipe. This being a long pipe line, we will neglect the velocity and entrance head.

Turning to the flow tables for 8″ pipe, we will arbitrarily pick some friction head, for example, 18′, and opposite this in the fourth column we find that it will discharge 2.16 c.f.s. Now, turning to the flow tables for 10″ pipe, we look in the fourth column for the above discharge of 2.16 and find 2.12, and opposite this in the first column we find the friction head loss to be 6′. As the length of each size of pipe is 5,000′, then the total lost head from friction would be the total friction head in the 8″ pipe plus the total friction head in the 10″ pipe, or 5 x 18 plus 5 x 6 = 120 feet. As this is more than the total head we have available, the values we assumed were too large. We now try a smaller value. For example, assume a friction head loss of 7′ for the 8″ pipe or a total of 7 x 5 = 35 feet. Opposite this 7 we find the discharge to be 1.28 cubic feet. Now, going to the 10″ pipe for a discharge of 1.28′, we find that it will require 2.5′ of head to overcome the friction in each 1,000′ of pipe or a total friction head loss of 2.5 x 5 = 12.5 feet. The total head of both sizes of pipe would then be 12.5 plus 35 = 47.5 feet, which is close enough to the actual total head of 48′ which is available. It can be seen from the above that the quantity of water which will be discharged through the 8″ and 10″ pipe will be 1.28 c.f.s.

This method of finding the quantity of water which

will flow through a pipe line of two different sizes of pipe is sufficiently accurate for all practical purposes and can be made even more accurate by interpolating between values in the flow tables.

The exact method for finding the discharge in this type of problem is to work out the Scobey formula direct. With the aid of the tables on pages 139 and 140, this is not very difficult.

$$Q = A_8V_8 = A_{10}V_{10}, \text{ or}$$

$$A_8V_8 = A_{10}V_{10}$$

From tables, pages 160 and 161, we find the areas:

$$\text{Then,} \quad V_8 = \frac{A_{10}V_{10}}{A_8} = \frac{.5454}{.3491} V_{10} = 1.563 \ V_{10}$$

From table, page 140, $1.563^{1.8} = 2.23$

$$V_8^{1.8} = 2.23 \ V_{10}^{1.8}$$

From the Scobey formula we know:

$$H_f = \frac{.419 \ L \ V_8^{1.8}}{D_8^{1.17}} + \frac{.419 \ L \ V_{10}^{1.8}}{D_{10}^{1.17}}$$

From the table, page 139, we find the values of $D^{1.17}$
Then, substituting in the above:

$$48 = \frac{(.419) \ (5000) \ V_8^{1.8}}{.6223} + \frac{(.419) \ (5000) \ V_{10}^{1.8}}{.8079} \quad \text{or}$$

$$48 = \frac{(2.095) \ (2.23) \ V_{10}^{1.8}}{.6223} + \frac{2.095 \ V_{10}^{1.8}}{.8079}$$

$$V_{10}^{1.8} = \frac{48}{10.11} = 4.747$$

From Table, Page 140, we find

$$V_{10} = 2.37$$

$$Q = A_{10}V_{10} = (.5454) \quad (2.38) = 1.29 \text{ c.f.s.}$$

As a comparison of the results obtained by the two different methods shows the difference to be very slight, either method can be used for all practical problems.

Flow of Water in Wood Stave Pipe

Diameter 2 Inches

Area 0.0218 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.141	**0.003**	1.4	.006
0.2	0.00	0.207	**0.005**	2.3	.010
0.3	0.00	0.259	**0.006**	2.7	.012
0.4	0.00	0.304	**0.007**	3.2	.014
0.5	0.00	0.344	**0.008**	3.6	.016
0.6	0.00	0.381	**0.008**	3.6	.016
0.7	0.00	0.415	**0.009**	4.0	.018
0.8	0.01	0.447	**0.010**	4.5	.020
0.9	0.01	0.477	**0.010**	4.5	.020
1.0	0.01	0.506	**0.011**	5.0	.022
1.5	0.01	0.633	**0.014**	6.3	.028
2.0	0.01	0.743	**0.016**	7.2	.032
2.5	0.02	0.841	**0.018**	8.1	.036
3.0	0.02	0.930	**0.020**	9.0	.040
3.5	0.03	1.01	**0.022**	9.9	.044
4.0	0.03	1.09	**0.024**	10.8	.048
4.5	0.03	1.17	**0.026**	11.7	.052
5.0	0.04	1.24	**0.027**	12.1	.054
6.0	0.05	1.37	**0.030**	13.5	.059
7.0	0.05	1.49	**0.033**	14.8	.065
8.0	0.06	1.60	**0.035**	15.7	.069
9.0	0.07	1.71	**0.037**	16.6	.073
10.0	0.08	1.82	**0.040**	18.0	.079
12.0	0.10	2.01	**0.044**	19.8	.087
14.0	0.11	2.19	**0.048**	21.6	.095
16.0	0.13	2.36	**0.052**	23.4	.103
18.0	0.15	2.51	**0.055**	24.7	.109
20.0	0.17	2.67	**0.058**	26.0	.115
22.0	0.19	2.81	**0.061**	27.4	.121
24.0	0.20	2.95	**0.064**	28.7	.127
26.0	0.22	3.08	**0.067**	30.1	.133
28.0	0.24	3.21	**0.070**	31.4	.139
30.0	0.26	3.34	**0.073**	32.8	.145
35.0	0.31	3.64	**0.079**	35.5	.157
40.0	0.36	3.92	**0.085**	38.1	.169
45.0	0.41	4.18	**0.091**	40.8	.180
50.0	0.46	4.43	**0.097**	43.5	.192

Wood pipe can be laid to the natural curvature of the ground without the use of special fittings, there being no sharp angles to cause friction loss.

Flow of Water in Wood Stave Pipe

Diameter 3 Inches

Area 0.0491 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.183	**0.009**	4.0	.018
0.2	0.00	0.269	**0.013**	5.8	.026
0.3	0.00	0.337	**0.017**	7.6	.034
0.4	0.00	0.396	**0.019**	8.5	.038
0.5	0.01	0.448	**0.022**	9.9	.044
0.6	0.01	0.496	**0.024**	10.8	.048
0.7	0.01	0.540	**0.026**	11.7	.052
0.8	0.01	0.581	**0.028**	12.6	.056
0.9	0.01	0.621	**0.030**	13.5	.060
1.0	0.01	0.658	**0.032**	14.4	.063
1.5	0.02	0.824	**0.040**	18.0	.079
2.0	0.02	0.967	**0.048**	21.5	.095
2.5	0.03	1.09	**0.054**	24.2	.107
3.0	0.03	1.21	**0.059**	26.5	.117
3.5	0.04	1.32	**0.065**	29.2	.129
4.0	0.05	1.42	**0.070**	31.4	.139
4.5	0.06	1.52	**0.075**	33.6	.149
5.0	0.06	1.61	**0.079**	35.4	.157
6.0	0.08	1.78	**0.087**	39.0	.172
7.0	0.09	1.94	**0.095**	42.6	.188
8.0	0.10	2.09	**0.102**	45.8	.202
9.0	0.12	2.23	**0.109**	49.0	.216
10.0	0.13	2.36	**0.116**	52.0	.230
12.0	0.16	2.61	**0.128**	57.4	.254
14.0	0.19	2.85	**0.140**	62.8	.278
16.0	0.22	3.07	**0.151**	67.8	.299
18.0	0.25	3.27	**0.160**	71.8	.317
20.0	0.28	3.47	**0.170**	76.3	.337
22.0	0.31	3.66	**0.180**	80.8	.357
24.0	0.35	3.84	**0.189**	84.8	.375
26.0	0.38	4.01	**0.197**	88.5	.391
28.0	0.41	4.18	**0.205**	92.1	.406
30.0	0.44	4.35	**0.214**	96.0	.424
35.0	0.52	4.73	**0.232**	104	.460
40.0	0.61	5.10	**0.250**	112	.496
45.0	0.69	5.44	**0.267**	120	.530
50.0	0.78	5.77	**0.283**	127	.561

It costs less money to install "National Quality" wood pipe than pipe made of other materials because it is light and can be installed without the use of expensive equipment.

Flow of Water in Wood Stave Pipe

Diameter 4 Inches

Area 0.0873 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.221	**0.019**	8.5	.038
0.2	0.00	0.325	**0.028**	12.6	.056
0.3	0.00	0.407	**0.036**	16.1	.071
0.4	0.01	0.477	**0.042**	18.8	.083
0.5	0.01	0.540	**0.047**	21.1	.093
0.6	0.01	0.597	**0.052**	23.3	.103
0.7	0.01	0.651	**0.057**	25.6	.113
0.8	0.01	0.701	**0.061**	27.4	.121
0.9	0.01	0.748	**0.065**	29.2	.129
1.0	0.02	0.793	**0.069**	31.0	.137
1.5	0.02	0.993	**0.087**	39.0	.172
2.0	0.03	1.17	**0.102**	45.7	.202
2.5	0.04	1.32	**0.115**	51.6	.228
3.0	0.05	1.46	**0.128**	57.4	.254
3.5	0.06	1.59	**0.139**	62.3	.276
4.0	0.07	1.71	**0.149**	66.8	.295
4.5	0.08	1.83	**0.160**	71.8	.317
5.0	0.09	1.94	**0.169**	75.8	.335
6.0	0.11	2.14	**0.187**	83.9	.371
7.0	0.13	2.34	**0.204**	91.5	.404
8.0	0.15	2.52	**0.220**	98.7	.436
9.0	0.17	2.69	**0.235**	106	.466
10.0	0.19	2.85	**0.249**	112	.494
12.0	0.23	3.15	**0.275**	123	.545
14.0	0.28	3.43	**0.300**	135	.595
16.0	0.32	3.70	**0.323**	145	.640
18.0	0.37	3.95	**0.345**	155	.684
20.0	0.41	4.18	**0.365**	164	.724
22.0	0.46	4.41	**0.385**	173	.764
24.0	0.50	4.63	**0.404**	181	.801
26.0	0.55	4.84	**0.422**	189	.837
28.0	0.59	5.04	**0.440**	197	.872
30.0	0.64	5.24	**0.458**	206	.908
35.0	0.76	5.71	**0.499**	224	.990
40.0	0.88	6.15	**0.536**	241	1.06
45.0	1.0	6.56	**0.573**	257	1.14
50.0	1.1	6.96	**0.608**	273	1.21

All types of pipe fittings for machine banded pipe are illustrated on pages 56 to 68.

Flow of Water in Wood Stave Pipe

Diameter 5 Inches

Area 0.1364 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.256	**0.035**	15.7	.069
0.2	0.00	0.375	**0.051**	22.9	.101
0.3	0.01	0.470	**0.064**	28.7	.127
0.4	0.01	0.552	**0.075**	33.6	.149
0.5	0.01	0.624	**0.085**	38.1	.169
0.6	0.01	0.691	**0.094**	42.2	.186
0.7	0.01	0.752	**0.102**	45.7	.202
0.8	0.02	0.810	**0.110**	49.3	.218
0.9	0.02	0.865	**0.118**	52.9	.234
1.0	0.02	0.917	**0.125**	56.0	.248
1.5	0.03	1.15	**0.157**	70.3	.311
2.0	0.04	1.35	**0.184**	82.5	.365
2.5	0.06	1.53	**0.209**	93.6	.414
3.0	0.07	1.69	**0.230**	103	.456
3.5	0.08	1.84	**0.251**	113	.497
4.0	0.09	1.98	**0.270**	121	.536
4.5	0.11	2.11	**0.288**	129	.571
5.0	0.12	2.24	**0.306**	137	.607
6.0	0.14	2.48	**0.338**	152	.670
7.0	0.17	2.70	**0.368**	165	.730
8.0	0.20	2.91	**0.397**	178	.787
9.0	0.23	3.11	**0.424**	190	.841
10.0	0.25	3.29	**0.448**	201	.889
12.0	0.31	3.64	**0.496**	223	.984
14.0	0.37	3.97	**0.542**	243	1.07
16.0	0.43	4.27	**0.583**	262	1.16
18.0	0.49	4.56	**0.622**	279	1.23
20.0	0.55	4.84	**0.660**	296	1.31
22.0	0.61	5.10	**0.696**	312	1.38
24.0	0.67	5.35	**0.730**	327	1.45
26.0	0.73	5.59	**0.762**	342	1.51
28.0	0.79	5.83	**0.795**	357	1.58
30.0	0.86	6.06	**0.827**	371	1.64
35.0	1.0	6.60	**0.900**	404	1.78
40.0	1.2	7.11	**0.970**	435	1.92
45.0	1.4	7.58	**1.03**	461	2.04
50.0	1.5	8.04	**1.10**	493	2.18

Machine banded pipe is easily connected to gate valves as illustrated on page 72.

Flow of Water in Wood Stave Pipe

Diameter 6 Inches

Area 0.1963 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.288	**0.057**	25.6	.113
0.2	0.00	0.423	**0.083**	37.2	.165
0.3	0.01	0.529	**0.104**	46.7	.206
0.4	0.01	0.621	**0.122**	54.7	.242
0.5	0.01	0.703	**0.138**	62.0	.274
0.6	0.01	0.778	**0.153**	68.7	.303
0.7	0.02	0.847	**0.166**	74.5	.329
0.8	0.02	0.912	**0.179**	80.4	.355
0.9	0.02	0.974	**0.191**	85.7	.379
1.0	0.02	1.03	**0.202**	90.7	.401
1.5	0.04	1.29	**0.253**	114	.502
2.0	0.05	1.52	**0.298**	134	.591
2.5	0.07	1.72	**0.337**	151	.668
3.0	0.08	1.90	**0.373**	167	.740
3.5	0.10	2.07	**0.406**	182	.805
4.0	0.12	2.23	**0.438**	197	.869
4.5	0.13	2.38	**0.467**	210	.926
5.0	0.15	2.52	**0.495**	222	.982
6.0	0.18	2.79	**0.548**	246	1.09
7.0	0.22	3.04	**0.597**	268	1.18
8.0	0.25	3.27	**0.642**	288	1.27
9.0	0.29	3.50	**0.688**	309	1.36
10.0	0.32	3.71	**0.729**	327	1.45
12.0	0.39	4.10	**0.806**	362	1.60
14.0	0.47	4.47	**0.878**	394	1.74
16.0	0.54	4.81	**0.945**	424	1.87
18.0	0.62	5.14	**1.01**	453	2.00
20.0	0.69	5.44	**1.07**	480	2.12
22.0	0.77	5.74	**1.13**	507	2.24
24.0	0.84	6.02	**1.18**	529	2.34
26.0	0.92	6.30	**1.24**	556	2.46
28.0	1.0	6.56	**1.29**	579	2.56
30.0	1.1	6.82	**1.34**	601	2.66
35.0	1.3	7.43	**1.46**	655	2.89
40.0	1.5	8.00	**1.57**	705	3.11
45.0	1.7	8.54	**1.68**	753	3.33
50.0	1.9	9.05	**1.78**	799	3.53

Wood pipe has a greater capacity than pipe made of other materials and always maintains its original capacity.

Flow of Water in Wood Stave Pipe

Diameter 8 Inches

Area 0.3491 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.347	**0.121**	54.3	.240
0.2	0.01	0.510	**0.178**	79.9	.353
0.3	0.01	0.638	**0.223**	100	.442
0.4	0.01	0.749	**0.262**	117	.520
0.5	0.02	0.847	**0.296**	133	.587
0.6	0.02	0.937	**0.327**	147	.649
0.7	0.03	1.02	**0.356**	160	.706
0.8	0.03	1.10	**0.384**	172	.762
0.9	0.03	1.17	**0.408**	183	.809
1.0	0.04	1.25	**0.436**	196	.865
1.5	0.06	1.56	**0.545**	245	1.08
2.0	0.08	1.83	**0.640**	287	1.27
2.5	0.10	2.07	**0.723**	325	1.43
3.0	0.12	2.29	**0.800**	359	1.59
3.5	0.15	2.50	**0.874**	392	1.73
4.0	0.17	2.69	**0.940**	422	1.86
4.5	0.19	2.87	**1.00**	449	1.98
5.0	0.22	3.04	**1.06**	476	2.10
6.0	0.27	3.37	**1.18**	530	2.34
7.0	0.31	3.67	**1.28**	574	2.54
8.0	0.36	3.95	**1.38**	620	2.74
9.0	0.41	4.21	**1.47**	660	2.91
10.0	0.47	4.47	**1.56**	700	3.09
12.0	0.57	4.94	**1.73**	776	3.43
14.0	0.68	5.39	**1.88**	844	3.73
16.0	0.79	5.80	**2.03**	911	4.03
18.0	0.89	6.19	**2.16**	970	4.28
20.0	1.0	6.56	**2.29**	1030	4.54
22.0	1.1	6.92	**2.41**	1080	4.78
24.0	1.2	7.26	**2.53**	1140	5.02
26.0	1.3	7.59	**2.65**	1190	5.26
28.0	1.5	7.91	**2.76**	1240	5.48
30.0	1.6	8.22	**2.87**	1290	5.69
35.0	1.9	8.95	**3.12**	1400	6.19
40.0	2.2	9.64	**3.37**	1510	6.68
45.0	2.5	10.3	**3.60**	1620	7.14
50.0	2.8	10.9	**3.81**	1710	7.56

The method of determining the amount of water available is fully described on pages 120 *to* 130.

Flow of Water in Wood Stave Pipe

Diameter 10 Inches

Area 0.5454 Sq. Ft.

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.00	0.401	**.219**	88	.434
0.2	0.01	0.589	**.322**	145	.639
0.3	0.01	0.738	**.403**	181	.798
0.4	0.02	0.865	**.472**	212	.936
0.5	0.02	0.979	**.534**	240	1.06
0.6	0.03	1.08	**.589**	265	1.17
0.7	0.03	1.18	**.644**	289	1.28
0.8	0.04	1.27	**.693**	311	1.37
0.9	0.04	1.36	**.742**	333	1.47
1.0	0.05	1.44	**.785**	352	1.56
1.2	0.06	1.59	**.868**	390	1.72
1.4	0.07	1.73	**.944**	423	1.87
1.6	0.08	1.87	**1.02**	458	2.02
1.8	0.09	1.99	**1.09**	490	2.16
2.0	0.11	2.11	**1.15**	517	2.28
2.5	0.13	2.39	**1.30**	584	2.58
3.0	0.16	2.65	**1.45**	651	2.88
3.5	0.19	2.88	**1.57**	705	3.11
4.0	0.23	3.11	**1.70**	764	3.37
4.5	0.26	3.32	**1.81**	813	3.59
5.0	0.29	3.52	**1.92**	863	3.81
6.0	0.35	3.89	**2.12**	953	4.20
7.0	0.42	4.24	**2.32**	1040	4.60
8.0	0.49	4.56	**2.49**	1120	4.94
9.0	0.55	4.87	**2.66**	1190	5.28
10.0	0.63	5.17	**2.82**	1270	5.59
12.0	0.76	5.71	**3.12**	1400	6.19
14.0	0.91	6.23	**3.40**	1530	6.74
16.0	1.1	6.70	**3.66**	1640	7.26
18.0	1.2	7.16	**3.91**	1760	7.76
20.0	1.4	7.59	**4.14**	1860	8.21
22.0	1.5	8.00	**4.36**	1960	8.65
24.0	1.7	8.40	**4.58**	2060	9.08
26.0	1.8	8.78	**4.79**	2150	9.50
28.0	2.0	9.15	**4.99**	2240	9.90
30.0	2.1	9.50	**5.18**	2330	10.3

The financial records of cities that have used wood pipe continuously will prove that it is the most economical means of transporting water.

Flow of Water in Wood Stave Pipe

Diameter 12 Inches

Area 0.7854 Sq. Ft.   (1 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.451	**0.354**	159	.702
0.2	0.01	0.663	**0.521**	234	1.03
0.3	0.02	0.831	**0.653**	293	1.29
0.4	0.02	0.974	**0.765**	343	1.52
0.5	0.03	1.10	**0.864**	388	1.71
0.6	0.04	1.22	**0.958**	430	1.90
0.7	0.04	1.33	**1.04**	467	2.06
0.8	0.05	1.43	**1.12**	503	2.22
0.9	0.05	1.53	**1.20**	539	2.38
1.0	0.06	1.62	**1.27**	570	2.52
1.2	0.08	1.79	**1.41**	633	2.80
1.4	0.09	1.95	**1.53**	686	3.03
1.6	0.11	2.10	**1.65**	740	3.27
1.8	0.12	2.25	**1.77**	794	3.51
2.0	0.13	2.38	**1.87**	840	3.71
2.5	0.17	2.69	**2.11**	947	4.18
3.0	0.21	2.98	**2.34**	1050	4.64
3.5	0.25	3.25	**2.55**	1140	5.06
4.0	0.29	3.50	**2.75**	1230	5.46
4.5	0.32	3.73	**2.93**	1310	5.81
5.0	0.37	3.96	**3.11**	1400	6.17
6.0	0.45	4.38	**3.45**	1550	6.84
7.0	0.53	4.77	**3.75**	1680	7.44
8.0	0.62	5.14	**4.04**	1810	8.01
9.0	0.70	5.48	**4.31**	1930	8.55
10.0	0.79	5.82	**4.57**	2050	9.06
12.0	0.97	6.43	**5.05**	2270	10.00
14.0	1.2	7.01	**5.51**	2470	10.9
16.0	1.3	7.55	**5.93**	2660	11.8
18.0	1.5	8.06	**6.33**	2840	12.6
20.0	1.7	8.54	**6.70**	3010	13.3
22.0	1.9	9.01	**7.08**	3180	14.0
24.0	2.1	9.45	**7.43**	3330	14.7
26.0	2.3	9.88	**7.76**	3480	15.4
28.0	2.5	10.3	**8.09**	3630	16.0
30.0	2.7	10.7	**8.40**	3770	16.6

The erection of wood pipe is a simple matter and can be accomplished without the use of expensive equipment.

Flow of Water in Wood Stave Pipe

Diameter 14 Inches

Area 1.069 Sq. Ft. (1 ft. 2 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.499	**0.534**	240	1.06
0.2	0.01	0.733	**0.784**	352	1.55
0.3	0.02	0.918	**0.983**	442	1.95
0.4	0.03	1.08	**1.16**	520	2.30
0.5	0.03	1.22	**1.30**	583	2.58
0.6	0.04	1.35	**1.44**	646	2.86
0.7	0.05	1.47	**1.57**	705	3.11
0.8	0.06	1.58	**1.69**	758	3.35
0.9	0.07	1.69	**1.81**	812	3.59
1.0	0.08	1.79	**1.92**	862	3.81
1.2	0.09	1.98	**2.12**	952	4.20
1.4	0.11	2.16	**2.31**	1040	4.58
1.6	0.13	2.33	**2.49**	1120	4.94
1.8	0.14	2.48	**2.65**	1190	5.26
2.0	0.16	2.63	**2.82**	1260	5.59
2.5	0.21	2.98	**3.19**	1430	6.33
3.0	0.25	3.30	**3.53**	1580	7.00
3.5	0.30	3.59	**3.84**	1720	7.62
4.0	0.35	3.87	**4.14**	1860	8.21
4.5	0.40	4.13	**4.42**	1980	8.77
5.0	0.45	4.38	**4.68**	2100	9.28
6.0	0.55	4.84	**5.18**	2320	10.30
7.0	0.65	5.27	**5.64**	2530	11.2
8.0	0.75	5.68	**6.08**	2730	12.1
9.0	0.86	6.06	**6.48**	2910	12.9
10.0	0.97	6.43	**6.87**	3090	13.6
12.0	1.2	7.11	**7.61**	3420	15.1
14.0	1.4	7.75	**8.29**	3720	16.4
16.0	1.6	8.34	**8.93**	4010	17.7
18.0	1.9	8.91	**9.53**	4280	18.9
20.0	2.1	9.45	**10.1**	4530	20.0
22.0	2.3	9.96	**10.7**	4800	21.2
24.0	2.6	10.5	**11.2**	5030	22.2
26.0	2.8	10.9	**11.7**	5250	23.2
28.0	3.0	11.4	**12.2**	5470	24.2
30.0	3.3	11.8	**12.6**	5650	25.0

Prompt delivery of "National Quality" wood stave pipe can be made as we maintain large stocks of materials and are prepared to meet practically any delivery requirement.

Flow of Water in Wood Stave Pipe

Diameter 16 Inches

Area 1.396 Sq. Ft. (1 ft. 4 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.544	**.760**	341	1.51
0.2	0.02	0.799	**1.11**	498	2.20
0.3	0.02	1.00	**1.40**	629	2.78
0.4	0.03	1.17	**1.63**	732	3.23
0.5	0.04	1.33	**1.86**	835	3.69
0.6	0.05	1.47	**2.05**	920	4.06
0.7	0.06	1.60	**2.23**	1000	4.42
0.8	0.07	1.73	**2.42**	1090	4.80
0.9	0.08	1.84	**2.57**	1150	5.10
1.0	0.09	1.95	**2.72**	1220	5.40
1.2	0.11	2.16	**3.02**	1350	5.99
1.4	0.13	2.35	**3.28**	1470	6.50
1.6	0.15	2.54	**3.55**	1590	7.04
1.8	0.17	2.71	**3.78**	1700	7.50
2.0	0.19	2.87	**4.01**	1800	7.95
2.5	0.25	3.25	**4.54**	2040	9.00
3.0	0.30	3.59	**5.01**	2250	9.94
3.5	0.36	3.91	**5.46**	2450	10.8
4.0	0.42	4.22	**5.89**	2640	11.7
4.5	0.47	4.50	**6.28**	2820	12.5
5.0	0.53	4.77	**6.66**	2990	13.2
6.0	0.65	5.28	**7.37**	3310	14.6
7.0	0.77	5.75	**8.03**	3610	15.9
8.0	0.89	6.19	**8.65**	3880	17.2
9.0	1.0	6.61	**9.23**	4140	18.3
10.0	1.2	7.01	**9.80**	4400	19.4
12.0	1.4	7.76	**10.8**	4850	21.4
14.0	1.7	8.45	**11.8**	5300	23.4
16.0	1.9	9.10	**12.7**	5700	25.2
18.0	2.2	9.71	**13.6**	6100	27.0
20.0	2.5	10.3	**14.4**	6460	28.6
22.0	2.8	10.9	**15.2**	6820	30.1
24.0	3.0	11.4	**15.9**	7140	31.5
26.0	3.3	11.9	**16.6**	7460	32.9
28.0	3.6	12.4	**17.3**	7770	34.3
30.0	3.9	12.9	**18.0**	8080	35.7

"National Quality" creosoted Douglas Fir pipe never requires cleaning or painting.

Flow of Water in Wood Stave Pipe

Diameter 18 Inches

Area 1.767 Sq. Ft. (1 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.588	**1.04**	467	2.06
0.2	0.02	0.863	**1.52**	682	3.01
0.3	0.03	1.08	**1.91**	858	3.79
0.4	0.04	1.27	**2.24**	1010	4.44
0.5	0.05	1.44	**2.54**	1140	5.04
0.6	0.06	1.59	**2.81**	1260	5.57
0.7	0.07	1.73	**3.06**	1370	6.07
0.8	0.08	1.86	**3.28**	1470	6.51
0.9	0.09	1.99	**3.51**	1580	6.96
1.0	0.10	2.11	**3.73**	1680	7.40
1.2	0.13	2.33	**4.12**	1850	8.17
1.4	0.15	2.54	**4.49**	2020	8.90
1.6	0.18	2.74	**4.84**	2170	9.60
1.8	0.20	2.92	**5.16**	2320	10.2
2.0	0.22	3.10	**5.48**	2460	10.9
2.5	0.29	3.51	**6.20**	2780	12.3
3.0	0.35	3.88	**6.86**	3080	13.6
3.5	0.42	4.23	**7.48**	3360	14.8
4.0	0.48	4.55	**8.05**	3610	16.0
4.5	0.55	4.86	**8.59**	3860	17.0
5.0	0.62	5.15	**9.10**	4080	18.0
6.0	0.76	5.70	**10.1**	4540	20.0
7.0	0.90	6.21	**11.0**	4940	21.8
8.0	1.0	6.69	**11.8**	5300	23.4
9.0	1.2	7.14	**12.6**	5660	25.0
10.0	1.3	7.57	**13.4**	6020	26.6
12.0	1.6	8.37	**14.8**	6650	29.3
14.0	1.9	9.12	**16.1**	7230	31.9
16.0	2.2	9.82	**17.3**	7770	34.3
18.0	2.6	10.5	**18.5**	8310	36.7
20.0	2.9	11.1	**19.6**	8800	38.9
22.0	3.2	11.7	**20.7**	9300	41.0
24.0	3.5	12.3	**21.7**	9750	43.0
26.0	3.9	12.9	**22.8**	10200	45.2
28.0	4.2	13.4	**23.7**	10600	47.0
30.0	4.5	13.9	**24.5**	11000	48.6

"National Quality" creosoted Douglas Fir pipe under ordinary conditions will give efficient service for 45 *to* 50 *years without appreciable maintenance cost.*

Flow of Water in Wood Stave Pipe

Diameter 20 Inches

Area 2.182 Sq. Ft. (1 ft. 8 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.629	**1.37**	615	2.72
0.2	0.02	0.924	**2.02**	907	4.01
0.3	0.03	1.16	**2.53**	1140	5.02
0.4	0.04	1.36	**2.97**	1330	5.89
0.5	0.06	1.54	**3.36**	1510	6.66
0.6	0.07	1.70	**3.71**	1670	7.36
0.7	0.08	1.85	**4.04**	1820	8.01
0.8	0.09	2.00	**4.37**	1960	8.67
0.9	0.11	2.13	**4.65**	2090	9.22
1.0	0.12	2.26	**4.94**	2220	9.80
1.2	0.15	2.50	**5.46**	2450	10.8
1.4	0.17	2.72	**5.94**	2670	11.8
1.6	0.20	2.93	**6.40**	2870	12.7
1.8	0.23	3.13	**6.84**	3070	13.6
2.0	0.26	3.32	**7.25**	3260	14.4
2.5	0.33	3.76	**8.22**	3690	16.3
3.0	0.40	4.16	**9.09**	4080	18.0
3.5	0.48	4.53	**9.90**	4450	19.6
4.0	0.55	4.87	**10.6**	4760	21.0
4.5	0.63	5.20	**11.3**	5080	22.4
5.0	0.71	5.52	**12.1**	5430	24.0
6.0	0.87	6.10	**13.3**	5970	26.4
7.0	1.0	6.65	**14.5**	6520	28.8
8.0	1.2	7.16	**15.6**	7000	30.9
9.0	1.4	7.65	**16.7**	7500	33.1
10.0	1.5	8.11	**17.7**	7950	35.1
12.0	1.9	8.97	**19.6**	8800	38.9
14.0	2.2	9.77	**21.3**	9570	42.2
16.0	2.6	10.5	**22.9**	10300	45.4
18.0	2.9	11.2	**24.5**	11000	48.6
20.0	3.3	11.9	**26.0**	11700	51.6
22.0	3.7	12.6	**27.5**	12300	54.6
24.0	4.1	13.2	**28.8**	12900	57.1
26.0	4.5	13.8	**30.1**	13500	59.7
28.0	4.8	14.4	**31.4**	14100	62.2
30.0	5.2	14.9	**32.5**	14600	64.4

Wood pipe will carry more water than pipe made of other materials as the inside always remains smooth and clean—free from rust, scale, and tuberculation.

Flow of Water in Wood Stave Pipe

Diameter 22 Inches

Area 2.640 Sq. Ft. (1 ft. 10 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.669	**1.76**	790	3.49
0.2	0.02	0.983	**2.60**	1170	5.16
0.3	0.04	1.23	**3.25**	1460	6.44
0.4	0.05	1.45	**3.83**	1720	7.60
0.5	0.06	1.64	**4.33**	1940	8.59
0.6	0.08	1.81	**4.77**	2140	9.46
0.7	0.09	1.97	**5.20**	2330	10.3
0.8	0.11	2.12	**5.59**	2510	11.1
0.9	0.12	2.27	**5.98**	2690	11.9
1.0	0.14	2.40	**6.33**	2840	12.6
1.2	0.17	2.66	**7.02**	3150	13.9
1.4	0.20	2.90	**7.66**	3440	15.2
1.6	0.23	3.12	**8.24**	3700	16.3
1.8	0.26	3.33	**8.79**	3940	17.4
2.0	0.29	3.53	**9.32**	4190	18.5
2.5	0.37	3.99	**10.5**	4720	20.8
3.0	0.46	4.42	**11.7**	5250	23.2
3.5	0.54	4.81	**12.7**	5700	25.2
4.0	0.63	5.19	**13.7**	6150	27.2
4.5	0.72	5.54	**14.6**	6550	29.0
5.0	0.80	5.87	**15.5**	6950	30.7
6.0	0.98	6.49	**17.2**	7720	34.1
7.0	1.2	7.07	**18.6**	8350	36.9
8.0	1.4	7.62	**20.1**	9030	39.9
9.0	1.5	8.13	**21.5**	9650	42.6
10.0	1.7	8.62	**22.8**	10200	45.2
12.0	2.1	9.54	**25.2**	11300	50.0
14.0	2.5	10.4	**27.5**	12300	54.6
16.0	2.9	11.2	**29.6**	13300	58.7
18.0	3.4	12.0	**31.7**	14200	62.9
20.0	3.8	12.7	**33.5**	15000	66.4
22.0	4.2	13.4	**35.4**	15900	70.2
24.0	4.6	14.0	**37.0**	16600	73.4
26.0	5.1	14.7	**38.8**	17400	77.0
28.0	5.5	15.3	**40.4**	18100	80.1

The simplicity with which "National Quality" wood pipe can be transported and installed is one of the reasons why it is being specified for important installations throughout the world.

Flow of Water in Wood Stave Pipe

Diameter 24 Inches

Area 3.142 Sq. Ft. (2 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.708	**2.22**	996	4.40
0.2	0.03	1.04	**3.27**	1470	6.48
0.3	0.04	1.30	**4.08**	1830	8.09
0.4	0.05	1.53	**4.81**	2160	9.54
0.5	0.07	1.73	**5.44**	2440	10.8
0.6	0.09	1.92	**6.04**	2710	12.0
0.7	0.10	2.09	**6.57**	2950	13.0
0.8	0.12	2.25	**7.07**	3170	14.0
0.9	0.13	2.40	**7.54**	3380	14.9
1.0	0.15	2.54	**7.98**	3580	15.8
1.2	0.18	2.81	**8.83**	3970	17.5
1.4	0.22	3.06	**9.61**	4320	19.0
1.6	0.25	3.30	**10.4**	4670	20.6
1.8	0.29	3.52	**11.1**	4980	22.0
2.0	0.33	3.74	**11.7**	5250	23.2
2.5	0.42	4.23	**13.3**	5970	26.4
3.0	0.51	4.68	**14.7**	6600	29.1
3.5	0.61	5.10	**16.0**	7180	31.7
4.0	0.70	5.49	**17.3**	7760	34.3
4.5	0.80	5.86	**18.4**	8260	36.5
5.0	0.90	6.21	**19.5**	8750	38.7
6.0	1.1	6.87	**21.6**	9700	42.8
7.0	1.3	7.49	**23.5**	10500	46.6
8.0	1.5	8.06	**25.4**	11400	50.4
9.0	1.7	8.61	**27.1**	12200	53.8
10.0	1.9	9.12	**28.7**	12900	56.9
12.0	2.4	10.1	**31.8**	14300	63.1
14.0	2.8	11.0	**34.6**	15500	68.6
16.0	3.2	11.8	**37.1**	16600	73.6
18.0	3.7	12.6	**39.6**	17800	78.6
20.0	4.2	13.4	**42.1**	18900	83.5
22.0	4.6	14.1	**44.3**	19900	87.9
24.0	5.1	14.8	**46.5**	20900	92.2
26.0	5.6	15.5	**48.7**	21900	96.6

"National Quality" continuous wood stave pipe has a distinct application in industrial installations where acid solutions are used. It can easily be connected with acid-resisting metal or rubber-lined steel fittings as illustrated on page 75.

Flow of Water in Wood Stave Pipe

Diameter 26 Inches

Area 3.687 Sq. Ft. (2 ft. 2 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.746	**2.75**	1230	5.46
0.2	0.03	1.10	**4.06**	1820	8.05
0.3	0.04	1.37	**5.05**	2270	10.0
0.4	0.06	1.61	**5.94**	2670	11.8
0.5	0.08	1.82	**6.71**	3010	13.3
0.6	0.10	2.02	**7.45**	3340	14.8
0.7	0.11	2.20	**8.11**	3640	16.1
0.8	0.13	2.37	**8.74**	3920	17.3
0.9	0.15	2.53	**9.33**	4190	18.5
1.0	0.17	2.68	**9.88**	4430	19.6
1.2	0.20	2.96	**10.9**	4900	21.6
1.4	0.24	3.23	**11.9**	5340	23.6
1.6	0.28	3.48	**12.8**	5750	25.4
1.8	0.32	3.71	**13.7**	6150	27.2
2.0	0.36	3.94	**14.5**	6510	28.8
2.5	0.46	4.45	**16.4**	7360	32.5
3.0	0.57	4.93	**18.2**	8170	36.1
3.5	0.67	5.37	**19.8**	8890	39.3
4.0	0.78	5.78	**21.3**	9560	42.2
4.5	0.89	6.17	**22.8**	10200	45.2
5.0	1.0	6.54	**24.1**	10800	47.8
6.0	1.2	7.24	**26.7**	12000	53.0
7.0	1.5	7.89	**29.1**	13100	57.7
8.0	1.7	8.49	**31.3**	14000	62.1
9.0	1.9	9.07	**33.4**	15000	66.2
10.0	2.2	9.61	**35.4**	15900	70.2
12.0	2.6	10.6	**39.1**	17600	77.6
14.0	3.1	11.6	**42.8**	19200	84.9
16.0	3.7	12.5	**46.1**	20700	91.4
18.0	4.1	13.3	**49.0**	22000	97.2
20.0	4.6	14.1	**52.0**	23400	103
22.0	5.2	14.9	**54.9**	24600	109
24.0	5.7	15.6	**57.5**	25800	114

Wood pipe is practically a non-conductor of heat, and water in it will not freeze under the ranges of temperature which would burst a metal pipe. Should the water in it freeze due to very low velocity and temperature, the flexibility of wood pipe prevents its bursting.

Flow of Water in Wood Stave Pipe

Diameter 28 Inches

Area 4.276 Sq. Ft. (2 ft. 4 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.01	0.783	**3.35**	1500	6.64
0.2	0.03	1.15	**4.92**	2210	9.76
0.3	0.05	1.44	**6.16**	2770	12.2
0.4	0.07	1.69	**7.23**	3250	14.3
0.5	0.09	1.91	**8.17**	3670	16.2
0.6	0.11	2.12	**9.06**	4070	18.0
0.7	0.12	2.31	**9.88**	4440	19.6
0.8	0.14	2.48	**10.6**	4760	21.0
0.9	0.16	2.65	**11.3**	5080	22.4
1.0	0.18	2.81	**12.0**	5390	23.8
1.2	0.23	3.11	**13.3**	5970	26.4
1.4	0.27	3.39	**14.5**	6510	28.7
1.6	0.31	3.65	**15.6**	7000	30.9
1.8	0.35	3.89	**16.6**	7450	32.9
2.0	0.40	4.13	**17.7**	7940	35.1
2.5	0.51	4.67	**20.0**	8980	39.7
3.0	0.62	5.17	**22.1**	9920	43.8
3.5	0.74	5.63	**24.1**	10800	47.8
4.0	0.86	6.07	**26.0**	11700	51.6
4.5	0.98	6.47	**27.7**	12400	54.9
5.0	1.1	6.86	**29.4**	13200	58.3
6.0	1.4	7.60	**32.5**	14600	64.4
7.0	1.6	8.27	**35.4**	15900	70.2
8.0	1.9	8.91	**38.1**	17100	75.6
9.0	2.1	9.51	**40.7**	18300	80.7
10.0	2.4	10.1	**43.2**	19400	85.7
11.0	2.6	10.6	**45.3**	20300	89.8
12.0	2.9	11.2	**47.9**	21500	95.0
13.0	3.2	11.7	**50.0**	22400	99.2
14.0	3.5	12.2	**52.2**	23500	103
16.0	4.0	13.1	**56.0**	25200	111
18.0	4.6	14.0	**59.9**	26900	119
20.0	5.1	14.8	**63.3**	28400	125
22.0	5.7	15.6	**66.7**	30000	132

Owing to its elasticity, wood pipe does not develop as much water hammer head as pipe made of rigid material and absorbs without injury a large portion of the excess pressure that is developed.

Flow of Water in Wood Stave Pipe

Diameter 30 Inches

Area 4.909 Sq. Ft. (2 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.819	**4.02**	1800	7.97
0.2	0.04	1.20	**5.89**	2640	11.7
0.3	0.06	1.51	**7.41**	3330	14.7
0.4	0.08	1.77	**8.70**	3900	17.3
0.5	0.10	2.00	**9.82**	4400	19.5
0.6	0.12	2.21	**10.8**	4850	21.4
0.7	0.14	2.41	**11.8**	5300	23.4
0.8	0.16	2.60	**12.8**	5740	25.4
0.9	0.18	2.77	**13.6**	6100	27.0
1.0	0.20	2.94	**14.4**	6460	28.6
1.2	0.25	3.25	**16.0**	7180	31.7
1.4	0.29	3.54	**17.4**	7810	34.5
1.6	0.34	3.82	**18.8**	8440	37.3
1.8	0.39	4.07	**20.0**	8980	39.7
2.0	0.44	4.32	**21.2**	9510	42.0
2.5	0.56	4.89	**24.0**	10800	47.6
3.0	0.68	5.41	**26.6**	11900	52.8
3.5	0.81	5.89	**28.9**	13000	57.3
4.0	0.94	6.34	**31.1**	13900	61.7
4.5	1.1	6.77	**33.3**	14900	66.0
5.0	1.2	7.18	**35.3**	15800	70.0
6.0	1.5	7.94	**39.0**	17500	77.4
7.0	1.7	8.65	**42.4**	19000	84.1
8.0	2.0	9.32	**45.8**	20600	90.8
9.0	2.3	9.95	**48.8**	21900	96.8
10.0	2.6	10.6	**52.1**	23400	103
11.0	2.9	11.1	**54.5**	24400	108
12.0	3.2	11.7	**57.4**	25800	114
13.0	3.5	12.2	**59.9**	26900	119
14.0	3.8	12.7	**62.4**	28000	124
16.0	4.4	13.7	**67.2**	30100	133
18.0	5.0	14.6	**71.7**	32200	142
20.0	5.6	15.5	**76.1**	34100	151

Wood pipe is not affected by electrolysis as the continuity of the metal banding is completely broken at each joint in machine banded pipe and at every band in continuous stave pipe.

Flow of Water in Wood Stave Pipe

Diameter 32 Inches

Area 5.585 Sq. Ft. (2 ft. 8 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.854	**4.77**	2140	9.46
0.2	0.04	1.26	**7.04**	3160	14.0
0.3	0.06	1.57	**8.77**	3930	17.4
0.4	0.08	1.84	**10.3**	4620	20.4
0.5	0.10	2.09	**11.7**	5250	23.2
0.6	0.12	2.31	**12.9**	5790	25.6
0.7	0.15	2.52	**14.1**	6320	28.0
0.8	0.17	2.71	**15.1**	6780	29.9
0.9	0.20	2.89	**16.1**	7220	31.9
1.0	0.22	3.07	**17.1**	7670	33.9
1.2	0.27	3.39	**18.9**	8480	37.5
1.4	0.32	3.69	**20.6**	9250	40.8
1.6	0.37	3.98	**22.2**	9960	44.0
1.8	0.42	4.25	**23.7**	10600	47.0
2.0	0.47	4.50	**25.1**	11300	49.8
2.5	0.61	5.10	**28.5**	12800	56.5
3.0	0.74	5.64	**31.5**	14100	62.5
3.5	0.88	6.14	**34.3**	15400	68.0
4.0	1.0	6.62	**37.0**	16600	73.4
4.5	1.2	7.06	**39.4**	17700	78.2
5.0	1.3	7.49	**41.8**	18800	82.9
6.0	1.6	8.29	**46.3**	20800	91.8
7.0	1.9	9.03	**50.4**	22600	100
8.0	2.2	9.72	**54.2**	24300	107
9.0	2.5	10.4	**58.1**	26100	115
10.0	2.8	11.0	**61.4**	27600	122
11.0	3.1	11.6	**64.8**	29100	128
12.0	3.5	12.2	**68.1**	30600	135
13.0	3.8	12.7	**71.0**	31800	141
14.0	4.1	13.3	**74.3**	33300	147
16.0	4.8	14.3	**79.9**	35800	158
18.0	5.4	15.2	**84.9**	38100	168

Wood pipe has neither longitudinal expansion nor contraction and, therefore, does not require expansion joints, which reflects a great saving in the cost between wood pipe and metal pipe.

Flow of Water in Wood Stave Pipe

Diameter 34 Inches

Area 6.305 Sq. Ft. (2 ft. 10 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.888	**5.60**	2510	11.1
0.2	0.04	1.31	**8.26**	3710	16.4
0.3	0.06	1.63	**10.3**	4620	20.4
0.4	0.09	1.92	**12.1**	5430	24.0
0.5	0.11	2.17	**13.7**	6150	27.2
0.6	0.14	2.40	**15.1**	6770	29.9
0.7	0.16	2.62	**16.5**	7400	32.7
0.8	0.19	2.82	**17.8**	7990	35.3
0.9	0.21	3.01	**19.0**	8530	37.7
1.0	0.24	3.19	**20.1**	9020	39.9
1.2	0.29	3.53	**22.3**	10000	44.2
1.4	0.34	3.84	**24.2**	10800	48.0
1.6	0.40	4.14	**26.1**	11700	51.8
1.8	0.46	4.42	**27.9**	12500	55.3
2.0	0.51	4.68	**29.5**	13200	58.5
2.5	0.66	5.30	**33.4**	15000	66.2
3.0	0.80	5.87	**37.0**	16600	73.4
3.5	0.95	6.39	**40.3**	18100	80.0
4.0	1.1	6.88	**43.4**	19500	86.1
4.5	1.3	7.35	**46.3**	20800	91.8
5.0	1.4	7.79	**49.1**	22000	97.4
6.0	1.7	8.62	**54.4**	24400	108
7.0	2.1	9.39	**59.2**	26600	117
8.0	2.4	10.1	**63.7**	28600	126
9.0	2.7	10.8	**68.1**	30600	135
10.0	3.0	11.4	**71.9**	32200	143
11.0	3.4	12.1	**76.3**	34200	151
12.0	3.8	12.7	**80.1**	36000	159
13.0	4.1	13.2	**83.2**	37300	165
14.0	4.5	13.8	**87.0**	39000	172
16.0	5.2	14.9	**94.0**	42200	186
18.0	5.9	15.9	**100**	44900	198

"National Quality" wood pipe is flexible and will withstand settling of the ground without cracking.

Flow of Water in Wood Stave Pipe

Diameter 36 Inches

Area 7.069 Sq. Ft. (3 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.922	**6.52**	2930	12.9
0.2	0.04	1.35	**9.55**	4280	18.9
0.3	0.07	1.70	**12.0**	5390	23.8
0.4	0.09	1.99	**14.1**	6320	28.0
0.5	0.12	2.25	**15.9**	7130	31.5
0.6	0.15	2.49	**17.6**	7900	34.9
0.7	0.17	2.71	**19.2**	8620	38.1
0.8	0.20	2.92	**20.6**	9250	40.8
0.9	0.23	3.12	**22.0**	9870	43.6
1.0	0.26	3.31	**23.4**	10500	46.4
1.2	0.31	3.66	**25.9**	11600	51.4
1.4	0.37	3.99	**28.2**	12600	55.9
1.6	0.43	4.30	**30.4**	13600	60.3
1.8	0.49	4.59	**32.4**	14500	64.3
2.0	0.55	4.86	**34.4**	15400	68.2
2.5	0.70	5.50	**38.9**	17400	77.2
3.0	0.86	6.09	**43.0**	19300	85.3
3.5	1.0	6.63	**46.8**	21000	92.8
4.0	1.2	7.14	**50.4**	22600	100
4.5	1.4	7.62	**53.9**	24200	107
5.0	1.5	8.08	**57.2**	25700	113
6.0	1.9	8.94	**63.2**	28400	125
7.0	2.2	9.74	**68.8**	30900	136
8.0	2.6	10.5	**74.2**	33300	147
9.0	2.9	11.2	**79.2**	35500	157
10.0	3.3	11.9	**84.1**	37800	167
11.0	3.6	12.5	**88.4**	39700	175
12.0	4.0	13.1	**92.6**	41600	184
13.0	4.4	13.7	**96.9**	43500	192
14.0	4.8	14.3	**101**	45300	200
16.0	5.5	15.4	**109**	48900	216

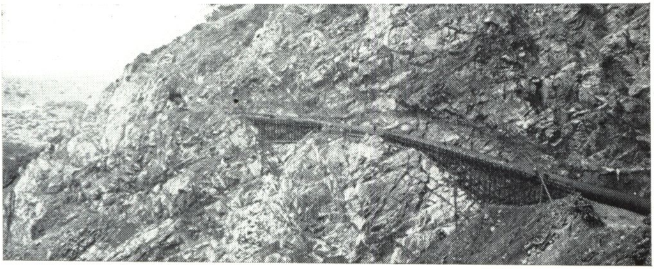
"National Quality" Wood Pipe

Flow of Water in Wood Stave Pipe

Diameter 38 Inches

Area 7.876 Sq. Ft. (3 ft. 2 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.955	**7.52**	3370	14.9
0.2	0.05	1.40	**11.0**	4940	21.8
0.3	0.07	1.76	**13.8**	6190	27.4
0.4	0.10	2.06	**16.2**	7270	32.1
0.5	0.13	2.33	**18.4**	8260	36.5
0.6	0.16	2.58	**20.3**	9110	40.2
0.7	0.18	2.81	**22.1**	9920	43.8
0.8	0.21	3.03	**23.8**	10700	47.2
0.9	0.24	3.23	**25.4**	11400	50.4
1.0	0.27	3.43	**27.0**	12100	53.5
1.2	0.33	3.79	**29.9**	13400	59.3
1.4	0.40	4.13	**32.5**	14600	64.4
1.6	0.46	4.45	**35.0**	15700	69.4
1.8	0.53	4.75	**37.4**	16800	74.2
2.0	0.59	5.04	**39.7**	17800	78.7
2.5	0.76	5.70	**44.9**	20100	89.0
3.0	0.93	6.31	**49.7**	22300	98.6
3.5	1.1	6.87	**54.2**	24300	107
4.0	1.3	7.40	**58.3**	26200	116
4.5	1.5	7.90	**62.2**	27900	123
5.0	1.6	8.37	**65.9**	29600	131
6.0	2.0	9.26	**73.0**	32800	145
7.0	2.4	10.1	**79.5**	35700	158
8.0	2.8	10.9	**85.9**	38600	170
9.0	3.1	11.6	**91.4**	41000	181
10.0	3.5	12.3	**96.9**	43500	192
11.0	3.9	13.0	**102**	45700	202
12.0	4.3	13.6	**107**	48000	212
13.0	4.7	14.2	**112**	50200	222
14.0	5.1	14.8	**117**	52500	232
16.0	6.0	16.0	**126**	56500	250



"National Quality" Wood Pipe

Flow of Water in Wood Stave Pipe

Diameter 40 Inches

Area 8.727 Sq. Ft. (3 ft. 4 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.02	0.987	**8.62**	3870	17.1
0.2	0.05	1.45	**12.6**	5650	25.0
0.3	0.08	1.82	**15.9**	7140	31.5
0.4	0.11	2.13	**18.6**	8350	36.9
0.5	0.14	2.41	**21.1**	9460	41.8
0.6	0.17	2.67	**23.3**	10400	46.2
0.7	0.20	2.91	**25.4**	11400	50.4
0.8	0.23	3.13	**27.3**	12300	54.2
0.9	0.26	3.34	**29.2**	13100	57.9
1.0	0.29	3.54	**30.9**	13900	61.3
1.2	0.36	3.92	**34.2**	15300	67.8
1.4	0.43	4.27	**37.3**	16700	74.0
1.6	0.49	4.60	**40.2**	18000	79.7
1.8	0.56	4.91	**42.8**	19200	84.9
2.0	0.63	5.21	**45.5**	20400	90.2
2.5	0.81	5.89	**51.4**	23100	102
3.0	0.99	6.52	**56.9**	25500	113
3.5	1.2	7.10	**62.0**	27800	123
4.0	1.4	7.65	**66.8**	30000	132
4.5	1.6	8.16	**71.2**	32000	141
5.0	1.8	8.66	**75.6**	33900	150
6.0	2.1	9.58	**83.7**	37600	166
7.0	2.5	10.4	**90.8**	40700	180
8.0	2.9	11.2	**97.8**	43900	194
9.0	3.3	12.0	**105**	47100	208
10.0	3.8	12.7	**111**	49800	220
11.0	4.2	13.4	**117**	52500	232
12.0	4.6	14.1	**123**	55200	244
13.0	5.0	14.7	**128**	57400	254
14.0	5.5	15.3	**134**	60100	266

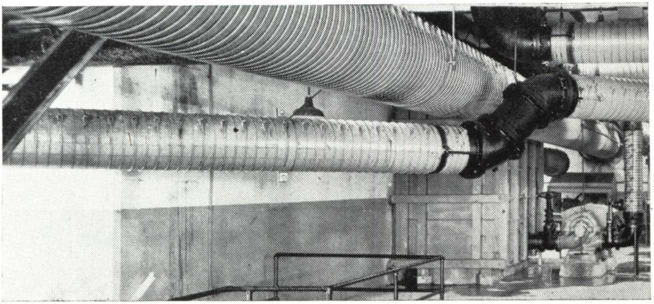
"National Quality" creosoted Douglas Fir wood stave pipe is extensively used for road culverts. Creosoted Douglas Fir culverts that were installed in 1896 are still in use and in excellent condition.

Flow of Water in Wood Stave Pipe

Diameter 42 Inches

Area 9.621 Sq. Ft. (3 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.02	**9.82**	4410	19.5
0.2	0.05	1.50	**14.4**	6460	28.5
0.3	0.08	1.88	**18.1**	8120	35.9
0.4	0.11	2.20	**21.2**	9500	42.0
0.5	0.14	2.49	**23.9**	10700	47.4
0.6	0.18	2.75	**26.4**	11800	52.4
0.7	0.21	3.00	**28.9**	13000	57.3
0.8	0.24	3.23	**31.1**	14000	61.7
0.9	0.28	3.45	**33.2**	14900	65.8
1.0	0.31	3.66	**35.2**	15800	69.8
1.2	0.38	4.05	**39.0**	17500	77.4
1.4	0.45	4.41	**42.4**	19000	84.1
1.6	0.53	4.75	**45.7**	20500	90.6
1.8	0.60	5.07	**48.8**	21900	96.8
2.0	0.67	5.37	**51.7**	23200	102
2.5	0.86	6.08	**58.5**	26300	116
3.0	1.1	6.73	**64.8**	29100	128
3.5	1.3	7.33	**70.5**	31700	140
4.0	1.5	7.89	**75.9**	34000	150
4.5	1.7	8.43	**81.2**	36500	161
5.0	1.9	8.94	**86.0**	38600	170
6.0	2.3	9.89	**95.2**	42700	189
7.0	2.7	10.8	**104**	46600	206
8.0	3.1	11.6	**111**	49800	220
9.0	3.6	12.4	**119**	53400	236
10.0	4.0	13.1	**126**	56500	250
11.0	4.4	13.8	**133**	59700	264
12.0	4.9	14.5	**140**	62800	278
13.0	5.4	15.2	**146**	65500	290



"National Quality" Wood Pipe

Flow of Water in Wood Stave Pipe

Diameter 44 Inches

Area 10.559 Sq. Ft. (3 ft. 8 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.05	**11.1**	4980	22.0
0.2	0.06	1.54	**16.3**	7320	32.3
0.3	0.09	1.93	**20.4**	9150	40.5
0.4	0.12	2.27	**24.0**	10800	47.6
0.5	0.15	2.57	**27.2**	12200	54.0
0.6	0.19	2.84	**30.0**	13500	59.5
0.7	0.22	3.09	**32.6**	14600	64.7
0.8	0.26	3.33	**35.2**	15800	69.8
0.9	0.30	3.56	**37.6**	16900	74.6
1.0	0.33	3.77	**39.8**	17800	79.0
1.2	0.41	4.17	**44.0**	19700	87.3
1.4	0.48	4.54	**48.0**	21600	95.2
1.6	0.56	4.89	**51.7**	23200	102
1.8	0.64	5.22	**55.2**	24800	109
2.0	0.72	5.54	**58.5**	26200	116
2.5	0.92	6.27	**66.2**	29700	131
3.0	1.1	6.94	**73.3**	32900	145
3.5	1.3	7.56	**79.9**	35800	158
4.0	1.5	8.14	**86.0**	38600	170
4.5	1.8	8.69	**91.8**	41200	182
5.0	2.0	9.21	**97.3**	43700	193
6.0	2.4	10.2	**108**	48500	214
7.0	2.9	11.1	**117**	52500	232
8.0	3.4	12.0	**127**	57000	252
9.0	3.8	12.8	**135**	60600	268
10.0	4.3	13.5	**143**	64200	283
11.0	4.8	14.3	**151**	67700	299
12.0	5.3	15.0	**158**	71000	313

Creosoted Douglas Fir is one of the finest materials for sewer pipe construction. It is not affected by sewer gas and will not rust, corrode, or tuberculate. It always maintains its original capacity.

Flow of Water in Wood Stave Pipe

Diameter 46 Inches

Area 11.541 Sq. Ft. (3 ft. 10 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.08	**12.5**	5610	24.8
0.2	0.06	1.59	**18.4**	8250	36.5
0.3	0.09	1.99	**23.0**	10300	45.6
0.4	0.13	2.33	**26.9**	12100	53.4
0.5	0.16	2.64	**30.5**	13700	60.5
0.6	0.20	2.92	**33.7**	15100	66.8
0.7	0.24	3.18	**36.7**	16500	72.8
0.8	0.27	3.43	**39.6**	17800	78.6
0.9	0.31	3.66	**42.3**	19000	83.9
1.0	0.35	3.88	**44.8**	20100	88.9
1.2	0.43	4.29	**49.6**	22300	98.4
1.4	0.51	4.68	**54.1**	24300	107
1.6	0.59	5.04	**58.2**	26100	115
1.8	0.67	5.38	**62.2**	27900	123
2.0	0.76	5.70	**65.8**	29600	130
2.5	0.97	6.45	**74.5**	33500	148
3.0	1.2	7.14	**82.5**	37000	163
3.5	1.4	7.78	**89.8**	40300	178
4.0	1.6	8.38	**96.9**	43500	192
4.5	1.9	8.94	**103**	46200	204
5.0	2.1	9.48	**109**	48900	216
6.0	2.6	10.5	**121**	54400	240
7.0	3.0	11.4	**132**	59200	262
8.0	3.5	12.3	**142**	63800	281
9.0	4.0	13.1	**151**	67800	299
10.0	4.5	13.9	**161**	72200	319
11.0	5.0	14.7	**170**	76300	337
12.0	5.5	15.4	**178**	80000	353

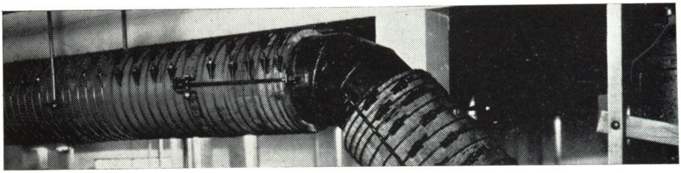
"National Quality" wood pipe is very economical for pumping plants as there is less friction in wood pipe than there is in pipe made of any other material and, consequently, less horse power is required to operate the pumps.

Flow of Water in Wood Stave Pipe

Diameter 48 Inches

Area 12.566 Sq. Ft. (4 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	*DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.11	**13.9**	6240	27.6
0.2	0.06	1.63	**20.5**	9210	40.6
0.3	0.10	2.05	**25.8**	11600	51.2
0.4	0.14	2.40	**30.1**	13500	59.7
0.5	0.17	2.72	**34.2**	15400	67.8
0.6	0.21	3.00	**37.7**	16900	74.8
0.7	0.25	3.27	**41.1**	18500	81.5
0.8	0.29	3.52	**44.2**	19800	87.7
0.9	0.33	3.76	**47.3**	21200	93.8
1.0	0.37	3.99	**50.2**	22500	99.6
1.2	0.45	4.41	**55.4**	24900	110
1.4	0.54	4.81	**60.5**	27200	120
1.6	0.63	5.18	**65.1**	29200	129
1.8	0.71	5.53	**69.5**	31200	138
2.0	0.80	5.86	**73.7**	33100	146
2.5	1.0	6.63	**83.3**	37400	165
3.0	1.3	7.34	**92.3**	41400	183
3.5	1.5	8.00	**101**	45300	200
4.0	1.7	8.61	**108**	48500	214
4.5	2.0	9.19	**115**	51600	228
5.0	2.2	9.75	**123**	55200	244
6.0	2.7	10.8	**136**	61100	270
7.0	3.2	11.8	**148**	66400	293
8.0	3.8	12.7	**160**	71800	317
9.0	4.3	13.5	**170**	76300	337
10.0	4.8	14.3	**180**	80800	357
11.0	5.3	15.1	**190**	85300	377



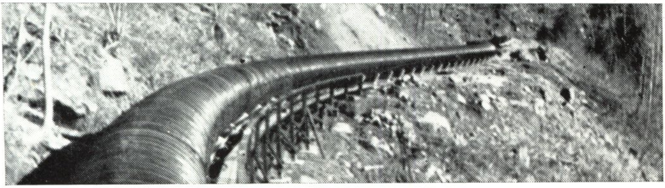
"National Quality"
Wolmanized Douglas Fir Industrial Pipe

Flow of Water in Wood Stave Pipe

Diameter 50 Inches

Area 13.635 Sq. Ft. (4 ft. 2 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.14	**15.5**	6960	30.7
0.2	0.07	1.68	**22.9**	10300	45.4
0.3	0.10	2.10	**28.7**	12900	56.9
0.4	0.14	2.46	**33.6**	15100	66.6
0.5	0.18	2.79	**38.1**	17100	75.6
0.6	0.22	3.09	**42.2**	18900	83.7
0.7	0.26	3.36	**45.8**	20600	90.8
0.8	0.31	3.62	**49.4**	22200	98.0
0.9	0.35	3.86	**52.7**	23600	104
1.0	0.39	4.10	**56.0**	25100	111
1.2	0.48	4.53	**61.9**	27800	123
1.4	0.57	4.94	**67.4**	30200	134
1.6	0.66	5.32	**72.6**	32600	144
1.8	0.75	5.68	**77.5**	34800	154
2.0	0.84	6.02	**82.1**	36900	163
2.5	1.1	6.81	**93.0**	41700	184
3.0	1.3	7.54	**103**	46200	204
3.5	1.6	8.21	**112**	50300	222
4.0	1.8	8.84	**121**	54300	240
4.5	2.1	9.44	**129**	57900	256
5.0	2.3	10.0	**136**	61000	270
6.0	2.9	11.1	**151**	67800	299
7.0	3.4	12.1	**165**	74000	327
8.0	3.9	13.0	**177**	79500	351
9.0	4.5	13.9	**190**	85300	377
10.0	5.0	14.7	**201**	90200	398
11.0	5.6	15.5	**211**	94700	418



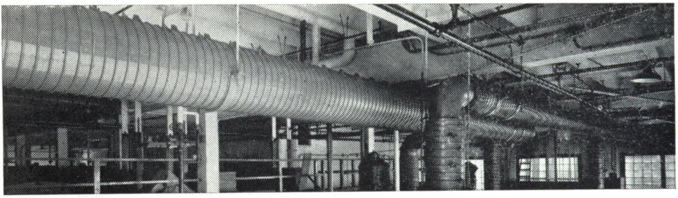
"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe

Flow of Water in Wood Stave Pipe

Diameter 52 Inches

Area 14.748 Sq. Ft. (4 ft. 4 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.17	**17.2**	7720	34.1
0.2	0.07	1.72	**25.3**	11400	50.2
0.3	0.11	2.15	**31.7**	14200	62.9
0.4	0.15	2.53	**37.3**	16700	74.0
0.5	0.19	2.86	**42.2**	18900	83.7
0.6	0.23	3.16	**46.6**	20900	92.4
0.7	0.28	3.45	**50.9**	22800	101
0.8	0.32	3.71	**54.7**	24600	108
0.9	0.36	3.96	**58.4**	26200	116
1.0	0.41	4.20	**62.0**	27800	123
1.2	0.50	4.65	**68.6**	30800	136
1.4	0.60	5.06	**74.6**	33500	148
1.6	0.69	5.45	**80.5**	36100	160
1.8	0.79	5.82	**85.8**	38500	170
2.0	0.89	6.17	**91.0**	40800	180
2.5	1.1	6.99	**103**	46200	204
3.0	1.4	7.73	**114**	51200	226
3.5	1.7	8.42	**124**	55600	246
4.0	1.9	9.07	**134**	60100	266
4.5	2.2	9.68	**143**	64200	284
5.0	2.5	10.3	**152**	68200	301
6.0	3.0	11.4	**168**	75400	333
7.0	3.6	12.4	**183**	82100	363
8.0	4.1	13.3	**196**	88000	389
9.0	4.7	14.2	**209**	93900	414
10.0	5.3	15.1	**223**	100000	442



"National Quality"
Untreated Douglas Fir Industrial Pipe

Flow of Water in Wood Stave Pipe

Diameter 54 Inches

Area 15.904 Sq. Ft. (4 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.03	1.20	**19.1**	8570	37.9
0.2	0.07	1.76	**28.0**	12600	55.6
0.3	0.11	2.21	**35.2**	15800	69.8
0.4	0.16	2.59	**41.3**	18500	81.9
0.5	0.20	2.93	**46.6**	20900	92.4
0.6	0.24	3.24	**51.6**	23200	102
0.7	0.29	3.53	**56.2**	25200	111
0.8	0.34	3.81	**60.6**	27200	120
0.9	0.38	4.06	**64.6**	29000	128
1.0	0.43	4.31	**68.6**	30800	136
1.2	0.53	4.77	**75.9**	34100	150
1.4	0.63	5.19	**82.6**	37100	164
1.6	0.73	5.59	**89.0**	39900	176
1.8	0.83	5.97	**95.0**	42600	188
2.0	0.93	6.33	**101**	45300	200
2.5	1.2	7.16	**114**	51200	226
3.0	1.5	7.92	**126**	56600	250
3.5	1.7	8.63	**137**	61500	272
4.0	2.0	9.30	**148**	66400	293
4.5	2.3	9.92	**158**	70900	313
5.0	2.6	10.5	**167**	75000	331
6.0	3.1	11.6	**185**	83000	367
7.0	3.7	12.7	**202**	90600	401
8.0	4.4	13.7	**218**	97900	432
9.0	5.0	14.6	**232**	104000	460
10.0	5.6	15.5	**247**	111000	490

"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe

Flow of Water in Wood Stave Pipe

Diameter 56 Inches

Area 17.104 Sq. Ft. (4 ft. 8 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.04	1.23	**21.0**	9430	41.6
0.2	0.08	1.81	**31.0**	13900	61.5
0.3	0.12	2.26	**38.7**	17400	76.8
0.4	0.16	2.65	**45.4**	20400	90.0
0.5	0.21	3.00	**51.3**	23000	102
0.6	0.26	3.32	**56.8**	25500	113
0.7	0.30	3.62	**62.0**	27800	123
0.8	0.35	3.90	**66.8**	30000	132
0.9	0.40	4.16	**71.2**	32000	141
1.0	0.45	4.41	**75.5**	33900	150
1.2	0.55	4.88	**83.7**	37600	166
1.4	0.66	5.32	**91.1**	40900	181
1.6	0.76	5.72	**98.0**	44000	194
1.8	0.87	6.11	**104**	46700	206
2.0	0.98	6.48	**111**	49800	220
2.5	1.3	7.33	**125**	56100	248
3.0	1.5	8.11	**139**	62400	276
3.5	1.8	8.84	**151**	67800	300
4.0	2.1	9.52	**163**	73200	323
4.5	2.4	10.2	**174**	78100	345
5.0	2.7	10.8	**185**	83000	367
6.0	3.3	11.9	**204**	91600	405
7.0	3.9	13.0	**222**	99600	440
8.0	4.6	14.0	**240**	108000	476
9.0	5.2	14.9	**255**	114000	506
10.0	5.8	15.8	**270**	121000	536

"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe

Flow of Water in Wood Stave Pipe

Diameter 58 Inches

Area 18.348 Sq. Ft. (4 ft. 10 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.04	1.26	**23.1**	10400	45.8
0.2	0.08	1.85	**33.9**	15200	67.2
0.3	0.13	2.31	**42.3**	19000	83.9
0.4	0.17	2.71	**49.7**	22300	98.6
0.5	0.22	3.07	**56.3**	25300	112
0.6	0.27	3.40	**62.4**	28000	124
0.7	0.32	3.70	**67.9**	30500	135
0.8	0.37	3.99	**73.2**	32900	145
0.9	0.43	4.26	**78.2**	35100	155
1.0	0.47	4.51	**82.7**	37100	164
1.2	0.58	4.99	**91.6**	41200	182
1.4	0.69	5.44	**99.8**	44800	198
1.6	0.80	5.86	**108**	48500	214
1.8	0.91	6.25	**115**	51600	228
2.0	1.0	6.63	**122**	54800	242
2.5	1.3	7.50	**138**	62000	274
3.0	1.6	8.30	**152**	68200	301
3.5	1.9	9.04	**166**	70000	329
4.0	2.2	9.74	**179**	80400	355
4.5	2.5	10.4	**191**	85800	379
5.0	2.8	11.0	**202**	90700	401
6.0	3.5	12.2	**224**	101000	444
7.0	4.1	13.3	**244**	110000	484
8.0	4.8	14.3	**262**	118000	520
9.0	5.5	15.3	**281**	126000	558

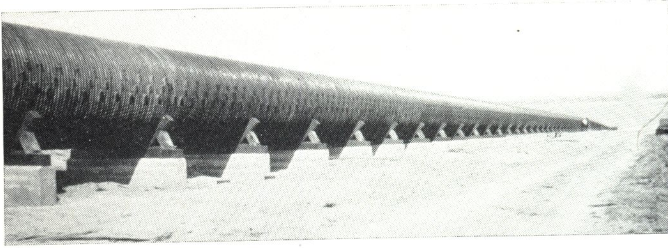
"National Quality"
Creosoted Douglas Fir Sewer Pipe

Flow of Water in Wood Stave Pipe

Diameter 60 Inches

Area 19.635 Sq. Ft. (5 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	DISCHARGE		
			Cubic Feet per Second	Gallons per Minute	Acre Feet per 24 Hours
0.1	0.04	1.29	**25.3**	11400	50.2
0.2	0.08	1.89	**37.1**	16700	73.6
0.3	0.13	2.36	**46.4**	20800	92.0
0.4	0.18	2.77	**54.4**	24400	108
0.5	0.23	3.14	**61.7**	27700	122
0.6	0.28	3.47	**68.2**	30600	135
0.7	0.33	3.78	**74.3**	33400	147
0.8	0.39	4.07	**80.0**	35900	159
0.9	0.44	4.35	**85.5**	38400	170
1.0	0.50	4.61	**90.6**	40700	180
1.2	0.61	5.10	**100**	44900	198
1.4	0.72	5.56	**109**	49000	216
1.6	0.84	5.99	**118**	53000	234
1.8	0.95	6.39	**126**	56600	250
2.0	1.1	6.78	**133**	59700	264
2.5	1.4	7.67	**151**	67800	299
3.0	1.7	8.49	**167**	75000	331
3.5	2.0	9.24	**182**	81700	361
4.0	2.3	9.95	**195**	87500	387
4.5	2.6	10.6	**208**	93500	413
5.0	3.0	11.3	**222**	99700	440
6.0	3.6	12.5	**246**	110000	488
7.0	4.3	13.6	**267**	120000	530
8.0	5.0	14.6	**287**	129000	569
9.0	5.7	15.6	**306**	137000	607



"National Quality"
Creosoted Douglas Fir Continuous Stave Pipe

Flow of Water in Wood Pipe

Area 23.76 Sq. Ft. Diameter 66 Inches (5 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.04	1.37	**32.6**	**1.6**	0.95	6.37	**151**
0.2	0.09	2.01	**47.8**	**1.8**	1.1	6.80	**162**
0.3	0.15	2.52	**59.9**	**2.0**	1.2	7.21	**171**
0.4	0.20	2.95	**70.1**	**2.5**	1.6	8.16	**194**
0.5	0.26	3.34	**79.4**	**3.0**	1.9	9.03	**215**
0.6	0.32	3.70	**88.0**	**3.5**	2.3	9.83	**234**
0.7	0.38	4.03	**95.8**	**4.0**	2.6	10.6	**252**
0.8	0.44	4.34	**103**	**4.5**	3.0	11.3	**268**
0.9	0.50	4.63	**110**	**5.0**	3.3	12.0	**285**
1.0	0.56	4.91	**117**	**6.0**	4.1	13.3	**316**
1.2	0.69	5.43	**129**	**7.0**	4.9	14.5	**344**
1.4	0.82	5.91	**140**	**8.0**	5.7	15.6	**371**

Area 28.27 Sq. Ft. Diameter 72 Inches (6 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.05	1.45	**41.0**	**1.6**	1.1	6.74	**191**
0.2	0.11	2.13	**60.3**	**1.8**	1.2	7.19	**203**
0.3	0.17	2.66	**75.2**	**2.0**	1.4	7.63	**216**
0.4	0.23	3.12	**88.3**	**2.5**	1.7	8.63	**244**
0.5	0.29	3.53	**99.8**	**3.0**	2.1	9.55	**270**
0.6	0.36	3.91	**110**	**3.5**	2.5	10.4	**294**
0.7	0.42	4.26	**120**	**4.0**	2.9	11.2	**317**
0.8	0.49	4.59	**130**	**4.5**	3.4	12.0	**339**
0.9	0.56	4.90	**139**	**5.0**	3.8	12.7	**359**
1.0	0.63	5.19	**147**	**6.0**	4.6	14.0	**396**
1.2	0.77	5.75	**163**	**7.0**	5.5	15.3	**433**
1.4	0.91	6.26	**177**				

Area 33.18 Sq. Ft. Diameter 78 Inches (6 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.05	1.52	**50.4**	**1.6**	1.2	7.10	**236**
0.2	0.12	2.24	**74.3**	**1.8**	1.3	7.58	**252**
0.3	0.18	2.80	**93.0**	**2.0**	1.5	8.04	**267**
0.4	0.25	3.29	**109**	**2.5**	1.9	9.09	**302**
0.5	0.32	3.72	**123**	**3.0**	2.4	10.1	**335**
0.6	0.40	4.12	**137**	**3.5**	2.8	11.0	**365**
0.7	0.47	4.49	**149**	**4.0**	3.3	11.8	**392**
0.8	0.54	4.83	**160**	**4.5**	3.7	12.6	**418**
0.9	0.62	5.16	**171**	**5.0**	4.2	13.4	**444**
1.0	0.70	5.47	**182**	**6.0**	5.1	14.8	**491**
1.2	0.85	6.05	**201**	**7.0**	6.0	16.1	**534**
1.4	1.0	6.59	**219**				

Flow of Water in Wood Pipe

Area 38.48 Sq. Ft. Diameter 84 Inches (7 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.06	1.60	**61.6**	**1.4**	1.1	6.92	**266**
0.2	0.13	2.35	**90.5**	**1.6**	1.3	7.45	**287**
0.3	0.20	2.94	**113**	**1.8**	1.5	7.95	**306**
0.4	0.28	3.45	**133**	**2.0**	1.7	8.43	**325**
0.5	0.36	3.91	**150**	**2.5**	2.1	9.54	**367**
0.6	0.44	4.32	**166**	**3.0**	2.6	10.6	**408**
0.7	0.52	4.71	**181**	**3.5**	3.1	11.5	**442**
0.8	0.60	5.07	**195**	**4.0**	3.6	12.4	**477**
0.9	0.68	5.41	**208**	**4.5**	4.1	13.2	**508**
1.0	0.77	5.74	**221**	**5.0**	4.6	14.0	**539**
1.2	0.94	6.35	**244**	**6.0**	5.6	15.5	**596**

Area 44.18 Sq. Ft. Diameter 90 Inches (7 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.07	1.67	**73.8**	**1.4**	1.2	7.23	**320**
0.2	0.14	2.46	**109**	**1.6**	1.4	7.79	**344**
0.3	0.22	3.08	**136**	**1.8**	1.6	8.32	**368**
0.4	0.30	3.61	**160**	**2.0**	1.8	8.82	**390**
0.5	0.39	4.09	**181**	**2.5**	2.3	9.98	**441**
0.6	0.48	4.52	**200**	**3.0**	2.8	11.0	**486**
0.7	0.57	4.92	**218**	**3.5**	3.4	12.0	**530**
0.8	0.66	5.30	**234**	**4.0**	3.9	13.0	**575**
0.9	0.75	5.66	**250**	**4.5**	4.4	13.8	**610**
1.0	0.84	6.00	**265**	**5.0**	5.0	14.7	**650**
1.2	1.0	6.64	**293**	**6.0**	6.1	16.2	**716**

Area 50.27 Sq. Ft. Diameter 96 Inches (8 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.07	1.74	**87.5**	**1.4**	1.3	7.54	**379**
0.2	0.15	2.56	**129**	**1.6**	1.5	8.13	**409**
0.3	0.24	3.21	**161**	**1.8**	1.8	8.67	**436**
0.4	0.33	3.76	**189**	**2.0**	2.0	9.20	**463**
0.5	0.42	4.26	**214**	**2.5**	2.5	10.4	**523**
0.6	0.52	4.71	**237**	**3.0**	3.1	11.5	**578**
0.7	0.62	5.14	**259**	**3.5**	3.7	12.6	**634**
0.8	0.71	5.53	**278**	**4.0**	4.3	13.5	**679**
0.9	0.81	5.90	**297**	**4.5**	4.8	14.4	**724**
1.0	0.92	6.26	**315**	**5.0**	5.5	15.3	**770**
1.2	1.1	6.93	**349**				

Flow of Water in Wood Pipe

Area 56.75 Sq. Ft. Diameter 102 Inches (8 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.07	1.81	**103**	**1.2**	1.2	7.20	**409**
0.2	0.17	2.67	**152**	**1.4**	1.4	7.85	**446**
0.3	0.26	3.34	**190**	**1.6**	1.7	8.45	**480**
0.4	0.36	3.92	**223**	**1.8**	1.9	9.02	**512**
0.5	0.46	4.43	**252**	**2.0**	2.1	9.57	**543**
0.6	0.56	4.90	**278**	**2.5**	2.7	10.8	**613**
0.7	0.66	5.34	**303**	**3.0**	3.4	12.0	**681**
0.8	0.77	5.75	**326**	**3.5**	4.0	13.1	**744**
0.9	0.88	6.14	**348**	**4.0**	4.6	14.1	**800**
1.0	0.99	6.51	**370**	**4.5**	5.3	15.0	**852**

Area 63.62 Sq. Ft. Diameter 108 Inches (9 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.08	1.88	**120**	**1.2**	1.3	7.48	**476**
0.2	0.18	2.77	**176**	**1.4**	1.6	8.15	**519**
0.3	0.28	3.46	**220**	**1.6**	1.8	8.77	**559**
0.4	0.38	4.06	**258**	**1.8**	2.0	9.36	**596**
0.5	0.49	4.60	**293**	**2.0**	2.3	9.93	**632**
0.6	0.60	5.09	**324**	**2.5**	2.9	11.2	**713**
0.7	0.72	5.54	**353**	**3.0**	3.6	12.4	**790**
0.8	0.83	5.97	**380**	**3.5**	4.3	13.5	**860**
0.9	0.95	6.37	**406**	**4.0**	5.0	14.6	**930**
1.0	1.1	6.76	**430**	**4.5**	5.7	15.6	**994**

Area 70.88 Sq. Ft. Diameter 114 Inches (9 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.1	0.09	1.95	**138**	**1.2**	1.4	7.74	**548**
0.2	0.19	2.87	**203**	**1.4**	1.7	8.44	**598**
0.3	0.30	3.59	**254**	**1.6**	1.9	9.09	**644**
0.4	0.42	4.21	**298**	**1.8**	2.2	9.70	**687**
0.5	0.53	4.76	**337**	**2.0**	2.5	10.3	**730**
0.6	0.65	5.27	**374**	**2.5**	3.1	11.6	**822**
0.7	0.77	5.74	**407**	**3.0**	3.9	12.9	**915**
0.8	0.89	6.18	**438**	**3.5**	4.6	14.0	**993**
0.9	1.0	6.60	**468**	**4.0**	5.3	15.1	**1070**
1.0	1.2	7.00	**496**				

Flow of Water in Wood Pipe

Area 78.54 Sq. Ft. Diameter 120 Inches (10 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.10	2.02	159	0.80	0.95	6.39	502
0.15	0.15	2.53	199	0.85	1.0	6.61	520
0.20	0.20	2.96	233	0.90	1.1	6.83	537
0.25	0.26	3.35	263	0.95	1.2	7.03	552
0.30	0.32	3.71	292	1.0	1.3	7.24	569
0.35	0.38	4.04	318	1.2	1.5	8.01	630
0.40	0.44	4.35	342	1.4	1.8	8.72	685
0.45	0.50	4.65	365	1.6	2.1	9.39	738
0.50	0.57	4.93	388	1.8	2.3	10.0	785
0.55	0.63	5.19	408	2.0	2.6	10.6	833
0.60	0.69	5.45	428	2.5	3.4	12.0	943
0.65	0.76	5.70	448	3.0	4.1	13.3	1040
0.70	0.82	5.94	467	3.5	4.9	14.5	1140
0.75	0.89	6.17	485	4.0	5.7	15.6	1230

Area 86.59 Sq. Ft. Diameter 126 Inches (10 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.10	2.08	180	0.80	1.0	6.60	571
0.15	0.16	2.61	226	0.85	1.1	6.83	591
0.20	0.22	3.06	265	0.90	1.2	7.05	610
0.25	0.28	3.46	300	0.95	1.2	7.26	629
0.30	0.34	3.83	332	1.0	1.3	7.47	647
0.35	0.41	4.17	361	1.2	1.6	8.27	716
0.40	0.47	4.49	389	1.4	1.9	9.00	780
0.45	0.54	4.80	415	1.6	2.2	9.70	840
0.50	0.60	5.08	440	1.8	2.5	10.4	900
0.55	0.67	5.36	464	2.0	2.8	11.0	953
0.60	0.74	5.63	488	2.5	3.6	12.4	1070
0.65	0.81	5.88	509	3.0	4.4	13.7	1190
0.70	0.88	6.13	531	3.5	5.2	15.0	1300
0.75	0.95	6.37	552				

Area 95.03 Sq. Ft. Diameter 132 Inches (11 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.11	2.15	204	0.80	1.1	6.80	646
0.15	0.17	2.69	256	0.85	1.2	7.04	669
0.20	0.23	3.15	300	0.90	1.2	7.26	690
0.25	0.30	3.57	339	0.95	1.3	7.48	711
0.30	0.36	3.95	375	1.0	1.4	7.70	732
0.35	0.43	4.30	409	1.2	1.7	8.52	810
0.40	0.50	4.63	440	1.4	2.0	9.28	883
0.45	0.57	4.94	470	1.6	2.3	9.99	950
0.50	0.64	5.24	498	1.8	2.7	10.7	1020
0.55	0.71	5.53	526	2.0	3.0	11.3	1070
0.60	0.78	5.80	551	2.5	3.8	12.8	1220
0.65	0.85	6.06	576	3.0	4.7	14.2	1350
0.70	0.93	6.32	601	3.5	5.5	15.4	1460
0.75	1.0	6.56	624				

Flow of Water in Wood Pipe

Area 103.87 Sq. Ft. Diameter 138 Inches (11 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.11	2.21	**230**	**0.80**	1.1	7.00	**727**
0.15	0.18	2.77	**288**	**0.85**	1.2	7.24	**752**
0.20	0.24	3.24	**337**	**0.90**	1.3	7.47	**776**
0.25	0.31	3.67	**381**	**0.95**	1.4	7.70	**800**
0.30	0.38	4.06	**422**	**1.0**	1.5	7.93	**824**
0.35	0.46	4.43	**460**	**1.2**	1.8	8.77	**911**
0.40	0.53	4.77	**496**	**1.4**	2.1	9.55	**992**
0.45	0.60	5.09	**529**	**1.6**	2.5	10.3	**1070**
0.50	0.68	5.39	**560**	**1.8**	2.8	11.0	**1140**
0.55	0.75	5.69	**592**	**2.0**	3.1	11.6	**1200**
0.60	0.83	5.97	**621**	**2.5**	4.1	13.2	**1370**
0.65	0.91	6.24	**648**	**3.0**	5.0	14.6	**1520**
0.70	0.99	6.50	**675**	**3.5**	5.9	15.9	**1650**
0.75	1.1	6.76	**702**				

Area 113.10 Sq. Ft. Diameter 144 Inches (12 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.12	2.27	**257**	**0.75**	1.1	6.95	**787**
0.15	0.19	2.84	**322**	**0.80**	1.2	7.20	**815**
0.20	0.26	3.34	**378**	**0.85**	1.3	7.44	**842**
0.25	0.33	3.77	**427**	**0.90**	1.4	7.68	**870**
0.30	0.41	4.18	**473**	**0.95**	1.5	7.92	**896**
0.35	0.48	4.55	**515**	**1.0**	1.6	8.15	**923**
0.40	0.56	4.90	**555**	**1.2**	1.9	9.01	**1020**
0.45	0.64	5.23	**592**	**1.4**	2.2	9.82	**1110**
0.50	0.72	5.55	**628**	**1.6**	2.6	10.6	**1200**
0.55	0.80	5.85	**662**	**1.8**	3.0	11.3	**1280**
0.60	0.88	6.14	**695**	**2.0**	3.4	12.0	**1360**
0.65	0.96	6.41	**726**	**2.5**	4.3	13.6	**1540**
0.70	1.0	6.68	**756**	**3.0**	5.2	15.0	**1700**

Area 122.72 Sq. Ft. Diameter 150 Inches (12 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.13	2.33	**286**	**0.75**	1.2	7.13	**875**
0.15	0.20	2.92	**358**	**0.80**	1.3	7.39	**906**
0.20	0.27	3.42	**419**	**0.85**	1.4	7.64	**937**
0.25	0.35	3.88	**476**	**0.90**	1.5	7.89	**968**
0.30	0.43	4.29	**527**	**0.95**	1.6	8.13	**997**
0.35	0.51	4.67	**573**	**1.0**	1.7	8.37	**1030**
0.40	0.59	5.03	**617**	**1.2**	2.0	9.26	**1140**
0.45	0.67	5.37	**659**	**1.4**	2.4	10.1	**1240**
0.50	0.76	5.69	**698**	**1.6**	2.8	10.9	**1340**
0.55	0.84	6.00	**736**	**1.8**	3.1	11.6	**1420**
0.60	0.92	6.30	**773**	**2.0**	3.5	12.3	**1510**
0.65	1.0	6.59	**809**	**2.5**	4.5	13.9	**1710**
0.70	1.1	6.86	**841**	**3.0**	5.5	15.4	**1810**

Flow of Water in Wood Pipe

Area 132.73 Sq. Ft. Diameter 156 Inches (13 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.13	2.39	**317**	**0.75**	1.3	7.32	**971**
0.15	0.21	2.99	**397**	**0.80**	1.3	7.58	**1010**
0.20	0.29	3.51	**466**	**0.85**	1.4	7.84	**1040**
0.25	0.37	3.98	**528**	**0.90**	1.5	8.09	**1070**
0.30	0.45	4.40	**584**	**0.95**	1.6	8.34	**1110**
0.35	0.54	4.79	**636**	**1.0**	1.7	8.58	**1140**
0.40	0.62	5.16	**685**	**1.2**	2.1	9.50	**1260**
0.45	0.71	5.51	**731**	**1.4**	2.5	10.3	**1370**
0.50	0.80	5.84	**775**	**1.6**	2.9	11.1	**1470**
0.55	0.89	6.16	**817**	**1.8**	3.3	11.9	**1580**
0.60	0.97	6.46	**857**	**2.0**	3.7	12.6	**1670**
0.65	1.1	6.76	**897**	**2.5**	4.8	14.3	**1900**
0.70	1.2	7.04	**934**	**3.0**	5.8	15.8	**2100**

Area 143.14 Sq. Ft. Diameter 162 Inches (13 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.14	2.45	**351**	**0.75**	1.3	7.50	**1070**
0.15	0.22	3.07	**440**	**0.80**	1.4	7.77	**1110**
0.20	0.30	3.60	**515**	**0.85**	1.5	8.04	**1150**
0.25	0.39	4.08	**585**	**0.90**	1.6	8.30	**1190**
0.30	0.47	4.51	**646**	**0.95**	1.7	8.55	**1220**
0.35	0.56	4.91	**703**	**1.0**	1.8	8.80	**1260**
0.40	0.65	5.29	**758**	**1.2**	2.2	9.73	**1390**
0.45	0.74	5.65	**810**	**1.4**	2.6	10.6	**1520**
0.50	0.84	5.99	**858**	**1.6**	3.0	11.4	**1630**
0.55	0.93	6.31	**904**	**1.8**	3.5	12.2	**1750**
0.60	1.0	6.62	**947**	**2.0**	3.9	12.9	**1850**
0.65	1.1	6.93	**993**	**2.5**	5.0	14.6	**2090**
0.70	1.2	7.22	**1030**	**3.0**	6.1	16.2	**2320**

Area 153.94 Sq. Ft. Diameter 168 Inches (14 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.15	2.51	**386**	**0.75**	1.4	7.68	**1180**
0.15	0.23	3.14	**483**	**0.80**	1.5	7.96	**1220**
0.20	0.32	3.69	**568**	**0.85**	1.6	8.23	**1270**
0.25	0.41	4.17	**642**	**0.90**	1.7	8.49	**1310**
0.30	0.50	4.62	**710**	**0.95**	1.8	8.75	**1350**
0.35	0.59	5.03	**774**	**1.0**	1.9	9.01	**1400**
0.40	0.68	5.42	**834**	**1.2**	2.3	9.96	**1530**
0.45	0.78	5.78	**889**	**1.4**	2.8	10.9	**1680**
0.50	0.88	6.13	**944**	**1.6**	3.2	11.7	**1800**
0.55	0.97	6.46	**994**	**1.8**	3.6	12.5	**1920**
0.60	1.1	6.78	**1040**	**2.0**	4.1	13.2	**2030**
0.65	1.2	7.09	**1090**	**2.5**	5.2	15.0	**2310**
0.70	1.3	7.39	**1140**				

Flow of Water in Wood Pipe

Area 165.13 Sq. Ft. Diameter 174 Inches (14 ft. 6 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.15	2.57	**424**	**0.75**	1.4	7.85	**1300**
0.15	0.24	3.22	**532**	**0.80**	1.6	8.14	**1340**
0.20	0.33	3.77	**623**	**0.85**	1.7	8.42	**1390**
0.25	0.43	4.27	**705**	**0.90**	1.8	8.69	**1440**
0.30	0.52	4.72	**780**	**0.95**	1.9	8.95	**1480**
0.35	0.62	5.15	**851**	**1.0**	2.0	9.21	**1520**
0.40	0.72	5.54	**899**	**1.2**	2.4	10.2	**1680**
0.45	0.82	5.92	**978**	**1.4**	2.9	11.1	**1830**
0.50	0.92	6.27	**1040**	**1.6**	3.4	12.0	**1980**
0.55	1.0	6.61	**1090**	**1.8**	3.8	12.8	**2120**
0.60	1.1	6.94	**1150**	**2.0**	4.3	13.5	**2230**
0.65	1.2	7.25	**1200**	**2.5**	5.5	15.3	**2530**
0.70	1.3	7.56	**1250**				

Area 176.72 Sq. Ft. Diameter 180 Inches (15 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.16	2.62	**463**	**0.75**	1.5	8.03	**1420**
0.15	0.25	3.29	**581**	**0.80**	1.6	8.32	**1470**
0.20	0.35	3.86	**682**	**0.85**	1.7	8.61	**1520**
0.25	0.44	4.36	**770**	**0.90**	1.8	8.88	**1570**
0.30	0.54	4.83	**853**	**0.95**	2.0	9.15	**1620**
0.35	0.65	5.26	**930**	**1.0**	2.1	9.42	**1660**
0.40	0.75	5.66	**1000**	**1.2**	2.5	10.4	**1840**
0.45	0.85	6.05	**1070**	**1.4**	3.0	11.4	**2010**
0.50	0.96	6.41	**1130**	**1.6**	3.5	12.2	**2160**
0.55	1.1	6.76	**1190**	**1.8**	4.0	13.1	**2320**
0.60	1.2	7.09	**1250**	**2.0**	4.4	13.8	**2440**
0.65	1.3	7.42	**1310**	**2.5**	5.7	15.7	**2770**
0.70	1.4	7.73	**1370**				

Area 201.06 Sq. Ft. Diameter 192 Inches (16 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.18	2.74	**551**	**0.75**	1.6	8.37	**1680**
0.15	0.27	3.43	**690**	**0.80**	1.8	8.68	**1750**
0.20	0.38	4.02	**808**	**0.85**	1.9	8.98	**1810**
0.25	0.48	4.55	**915**	**0.90**	2.0	9.26	**1860**
0.30	0.59	5.04	**1010**	**0.95**	2.1	9.55	**1920**
0.35	0.70	5.49	**1100**	**1.0**	2.2	9.82	**1970**
0.40	0.81	5.91	**1190**	**1.2**	2.8	10.9	**2190**
0.45	0.93	6.31	**1270**	**1.4**	3.2	11.8	**2370**
0.50	1.0	6.69	**1350**	**1.6**	3.8	12.8	**2570**
0.55	1.2	7.05	**1420**	**1.8**	4.3	13.6	**2730**
0.60	1.3	7.40	**1490**	**2.0**	4.8	14.4	**2890**
0.65	1.4	7.73	**1550**	**2.5**	6.2	16.3	**3280**
0.70	1.5	8.06	**1620**				

Flow of Water in Wood Pipe

Area 226.98 Sq. Ft. Diameter 204 Inches (17 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.19	2.85	**647**	**0.70**	1.6	8.38	**1900**
0.15	0.30	3.57	**810**	**0.75**	1.8	8.71	**1980**
0.20	0.41	4.18	**949**	**0.80**	1.9	9.03	**2050**
0.25	0.52	4.73	**1070**	**0.85**	2.0	9.34	**2120**
0.30	0.64	5.24	**1190**	**0.90**	2.2	9.64	**2190**
0.35	0.76	5.71	**1300**	**0.95**	2.3	9.93	**2250**
0.40	0.88	6.14	**1390**	**1.0**	2.4	10.2	**2310**
0.45	1.0	6.56	**1490**	**1.2**	3.0	11.3	**2560**
0.50	1.1	6.95	**1580**	**1.4**	3.5	12.3	**2790**
0.55	1.3	7.33	**1660**	**1.6**	4.1	13.3	**3020**
0.60	1.4	7.69	**1740**	**1.8**	4.7	14.2	**3220**
0.65	1.5	8.04	**1820**	**2.0**	5.2	15.0	**3400**

Area 254.47 Sq. Ft. Diameter 216 Inches (18 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.20	2.95	**751**	**0.70**	1.8	8.70	**2210**
0.15	0.32	3.70	**942**	**0.75**	1.9	9.04	**2300**
0.20	0.44	4.34	**1100**	**0.80**	2.0	9.37	**2380**
0.25	0.56	4.91	**1250**	**0.85**	2.2	9.69	**2460**
0.30	0.69	5.44	**1380**	**0.90**	2.3	10.0	**2540**
0.35	0.82	5.92	**1510**	**0.95**	2.5	10.3	**2620**
0.40	0.95	6.38	**1620**	**1.0**	2.6	10.6	**2700**
0.45	1.1	6.81	**1730**	**1.2**	3.2	11.7	**2980**
0.50	1.2	7.22	**1840**	**1.4**	3.8	12.8	**3260**
0.55	1.4	7.61	**1940**	**1.6**	4.4	13.8	**3510**
0.60	1.5	7.99	**2030**	**1.8**	5.0	14.7	**3740**
0.65	1.6	8.35	**2120**	**2.0**	5.7	15.6	**3970**

Area 283.53 Sq. Ft. Diameter 228 Inches (19 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.22	3.06	**868**	**0.70**	1.9	9.01	**2550**
0.15	0.34	3.83	**1090**	**0.75**	2.0	9.36	**2650**
0.20	0.47	4.50	**1280**	**0.80**	2.2	9.70	**2750**
0.25	0.60	5.09	**1440**	**0.85**	2.3	10.0	**2840**
0.30	0.74	5.63	**1600**	**0.90**	2.5	10.4	**2950**
0.35	0.88	6.13	**1740**	**0.95**	2.7	10.7	**3030**
0.40	1.0	6.61	**1870**	**1.0**	2.8	11.0	**3120**
0.45	1.2	7.05	**2000**	**1.2**	3.5	12.2	**3460**
0.50	1.3	7.48	**2120**	**1.4**	4.1	13.2	**3740**
0.55	1.5	7.88	**2230**	**1.6**	4.8	14.3	**4050**
0.60	1.6	8.27	**2340**	**1.8**	5.4	15.2	**4310**
0.65	1.7	8.65	**2450**				

Flow of Water in Wood Pipe

Area 314.16 Sq. Ft. Diameter 240 Inches (20 ft. 0 in.)

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity and Entrance Head in Feet	Velocity in Feet per Second	Discharge Cubic Feet per Second
0.10	0.23	3.16	**993**	**0.70**	2.0	9.32	**2930**
0.15	0.37	3.96	**1240**	**0.75**	2.2	9.68	**3040**
0.20	0.50	4.65	**1460**	**0.80**	2.3	10.0	**3140**
0.25	0.65	5.26	**1650**	**0.85**	2.5	10.4	**3270**
0.30	0.79	5.82	**1830**	**0.90**	2.7	10.7	**3360**
0.35	0.94	6.34	**1990**	**0.95**	2.8	11.0	**3450**
0.40	1.1	6.83	**2150**	**1.0**	3.0	11.4	**3580**
0.45	1.2	7.29	**2290**	**1.2**	3.7	12.6	**3960**
0.50	1.4	7.73	**2430**	**1.4**	4.4	13.7	**4300**
0.55	1.6	8.15	**2560**	**1.6**	5.0	14.7	**4620**
0.60	1.7	8.55	**2690**	**1.8**	5.7	15.7	**4930**
0.65	1.9	8.94	**2810**				

Port of Portland

The Port of Portland has excellent facilities for handling export shipments of wood pipe. Direct shipment can be made from Portland to most ports of the world. Portland is also served by five transcontinental railroads and a very efficient system of auto freight carriers.

Carrying Capacity of Standard Screw Pipe

Giving loss of head per 100 feet of standard wrought iron or steel pipe joined with screw couplings.

Flow in Gallons per Minute	Nominal Diameter of Pipe							
	3/8″	1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″
1	6.4	2.1	......	......	......	......	......	......
2	23.3	7.4	1.9	......	......	......	......	......
3	49.0	15.8	4.1	1.3	......	......	......	......
4	84.0	27.0	7.0	2.1	.6	......	......	......
5	126.0	41.0	10.5	3.3	.8	.4	......	......
6	......	57.0	14.7	4.6	1.2	.6	.2	......
8	......	98.0	25.0	7.8	2.0	1.0	.3	.11
10	......	147.0	38.0	11.7	3.0	1.4	.5	.17
12	......	......	53.0	16.4	4.3	2.0	.8	.23
14	......	......	71.0	22.0	5.7	2.7	.9	.32
16	......	......	90.0	28.0	7.3	3.4	1.2	.42
18	......	......	111.0	35.0	9.1	4.2	1.5	.50
20	......	......	136.0	42.0	11.1	5.2	1.8	.61
25	......	......	......	64.0	16.6	7.9	2.7	.92
30	......	......	......	89.0	23.0	11.0	3.8	1.29
35	......	......	......	119.0	31.2	14.7	5.1	1.7
40	......	......	......	152.0	40.0	18.8	6.6	2.2
50	......	......	......	......	60.0	28.3	9.9	3.3
60	......	......	......	......	85.0	39.6	13.9	4.7
70	......	......	......	......	113.0	53.0	18.4	6.2
80	......	......	......	......	145.0	68.0	23.7	7.9
90	......	......	......	......	180.0	84.0	29.4	9.8
100	......	......	......	......	......	102.0	35.8	12.0
120	......	......	......	......	......	143.0	50.0	16.8
140	......	......	......	......	......	190.0	67.0	22.3
160	......	......	......	......	......	......	86.0	29.0
180	......	......	......	......	......	......	107.0	35.7
200							129.0	43.1
220	......	......	......	......	......	......	154.0	52.0
240	......	......	......	......	......	......	182.0	61.0
260	......	......	......	......	......	......	211.0	70.0
280	......	......	......	......	......	......	......	81.0
300	......	......	......	......	......	......	......	92.0

From Hazen-Williams Formula
C = 100

Wood pipe will always deliver the water with its natural purity unchanged. The inside of this pipe will always remain clean and free from rust, scale, and tuberculation.

Theoretical Discharge of Nozzles

U. S. Gallons per Minute

Head		Velocity of Disch.	Diameter of Nozzles in Inches										
lbs.	feet	Ft./Sec.	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
10	23.1	38.6	3.32	5.91	13.3	23.6	36.9	53.1	72.4	94.5	120	148	179
15	34.6	47.25	4.06	7.24	16.3	28.9	45.2	65.0	88.5	116.	147	181	219
20	46.2	54.55	4.69	8.35	19.8	33.4	52.2	75.1	102.	134.	169	209	253
25	57.7	61.0	5.25	9.34	21.0	37.3	58.3	84.0	114.	149.	189	234	283
30	69.3	66.85	5.75	10.2	23.0	40.9	63.9	92.0	125.	164.	207	256	309
35	80.8	72.2	6.21	11.1	24.8	44.2	69.0	99.5	135.	177.	224	277	334
40	92.4	77.2	6.64	11.8	26.6	47.3	73.8	106.	145.	188.	239	296	357
45	103.9	81.8	7.03	12.5	28.2	50.1	78.2	113.	153.	200.	253	313	379
50	115.5	86.25	7.41	13.2	29.7	52.8	82.5	119.	162.	211.	267	330	399
55	127.0	90.5	7.77	13.8	31.1	55.3	86.4	125.	169.	221.	280	346	418
60	138.6	94.5	8.12	14.5	32.5	57.8	90.4	130.	177.	231.	293	362	438
65	150.1	98.3	8.45	15.1	33.8	60.2	94.0	136.	184.	241.	305	376	455
70	161.7	102.1	8.78	15.7	35.2	62.5	97.7	141.	191.	250.	317	391	473
75	173.2	105.7	9.08	16.2	36.4	64.7	101.	146.	198.	259.	327	404	489
80	184.8	109.1	9.39	16.7	37.6	66.8	104.	150.	205.	267.	338	418	505
85	196.3	112.5	9 67	17.3	38.8	68.9	108.	155.	211.	276.	349	431	521
90	207.9	115.8	9.95	17.7	39.9	70.8	111.	160.	217.	284.	359	443	536
95	219.4	119.0	10.2	18.2	41.0	72.8	114.	164.	223.	292.	369	456	551
100	230.9	122.0	10.5	18.7	42.1	74.7	117	168.	229.	299.	378	467	565
105	242.4	125.0	10.8	19.2	43.1	76.5	120.	172.	234.	306.	388	479	579
110	254.0	128.0	11.0	19.6	44.1	78.4	122.	176.	240.	314.	397	490	593
115	265.5	130.9	11.2	20.0	45.1	80.1	125.	180.	245.	320.	406	501	606
120	277.1	133.7	11.5	20.5	46.0	81.8	128.	184.	251.	327.	414	512	619
125	288.6	136.4	11.7	20.9	47.0	83.5	130.	188.	256.	334.	423	522	632
130	300.2	139.1	12.0	21.3	48.0	85.2	133.	192.	261.	341.	432	533	645
135	311.7	141.8	12.2	21.7	48.9	86.7	136.	195.	266.	347.	439	543	656
140	323.3	144.3	12.4	22.1	49.8	88.4	138.	199.	271.	354.	448	553	668
145	334.8	146.9	12.6	22.5	50.6	89.9	140.	202.	275.	360.	455	562	680
150	346.4	149.5	12.9	22.9	51.6	91.5	143.	206.	280.	366.	463	572	692

lbs.	feet	Ft./Sec.	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5
10	23.1	38.6	213	289	378	479	591	714	851	1158	1510	1915	2365
15	34.6	47.25	260	354	463	585	723	874	1041	1418	1850	2345	2890
20	46.2	54.55	301	409	535	676	835	1009	1203	1638	2135	2710	3340
25	57.7	61.0	336	458	598	756	934	1128	1345	1830	2385	3025	3730
30	69.3	66.85	368	501	655	828	1023	1236	1473	2005	2615	3315	4090
35	80.8	72.2	398	541	708	895	1106	1335	1591	2168	2825	3580	4415
40	92.4	77.2	425	578	756	957	1182	1428	1701	2315	3020	3830	4725
45	103.9	81.8	451	613	801	1015	1252	1512	1802	2455	3200	4055	5000
50	115.5	86.25	475	647	845	1070	1320	1595	1900	2590	3375	4275	5280
55	127.0	90.4	498	678	886	1121	1385	1671	1991	2710	3540	4480	5530
60	138.6	94.5	521	708	926	1172	1447	1748	2085	2835	3700	4685	5790
65	150.1	98.3	542	737	964	1220	1506	1819	2165	2950	3850	4875	6020
70	161.7	102.1	563	765	1001	1267	1565	1888	2250	3065	4000	5060	6250
75	173.2	105.7	582	792	1037	1310	1619	1955	2330	3170	4135	5240	6475
80	184.8	109.1	602	818	1070	1354	1672	2020	2405	3280	4270	5410	6690
85	196.3	112.5	620	844	1103	1395	1723	2080	2480	3375	4400	5575	6890
90	207.9	115.8	638	868	1136	1436	1773	2140	2550	3475	4530	5740	7090
95	219.4	119.0	656	892	1168	1476	1824	2200	2625	3570	4655	5900	7290
100	230.9	122.0	672	915	1196	1512	1870	2255	2690	3660	4775	6050	7470
105	242.4	125.0	689	937	1226	1550	1916	2312	2755	3750	4890	6200	7650
110	254.0	128.0	705	960	1255	1588	1961	2366	2820	3840	5010	6340	7840
115	265.5	130.9	720	980	1282	1621	2005	2420	2885	3930	5120	6490	8010
120	277.1	133.7	736	1002	1310	1659	2050	2470	2945	4015	5225	6630	8180
125	288.6	136.4	751	1022	1338	1690	2090	2520	3005	4090	5340	6760	8350
130	300.2	139.1	767	1043	1365	1726	2132	2575	3070	4175	5450	6900	8530
135	311.7	141.8	780	1063	1390	1759	2173	2620	3125	4250	5550	7030	8680
140	323.3	144.3	795	1082	1415	1790	2212	2760	3180	4330	5650	7160	8850
145	334.8	146.9	809	1100	1440	1820	2250	2715	3235	4410	5740	7280	8990
150	346.4	149.5	824	1120	1466	1853	2290	2760	3295	4485	5850	7410	9150

The actual quantity discharged by a nozzle will be less than above table. A well tapered smooth nozzle may be assumed to give above 94% of the values in tables.

WOOD STAVE FLUME

Kutter Formula: The calculation of the flow of water in semi-circular wood flumes on the following pages is based on the formula for the calculation of the flow of water in open channels, $V = C\sqrt{RS}$, derived in 1775 by Chezy, the French engineer. The coefficient "C" in the Chezy formula may be calculated by the Kutter formula

$$C = \frac{41.65 + \frac{0.00281}{S} + \frac{1.811}{\text{“}n\text{”}}}{1 + \left[41.65 + \frac{0.00281}{S}\right]\frac{\text{“}n\text{”}}{\sqrt{R}}}$$

which takes into consideration the slope of the hydraulic gradient, the hydraulic radius, and the unknown coefficient of roughness "n."

Wetted Perimeter: The wetted perimeter is that portion of the perimeter of the cross-section of the waterway in contact with the liquid. For example, a box flume 3′ wide with water running 2′ deep would have a wetted perimeter of 3 + 2 + 2 = 7′.

Hydraulic Radius: The hydraulic radius of a channel is equal to the cross-sectional area in square feet divided by the wetted perimeter. In the previous example of the box flume, the wetted perimeter was 7′. The cross-section area would be 2′ x 3′ = 6′. The hydraulic radius would then be 6 divided by 7 = 0.857.

Velocity Head: The velocity head loss, according to the definition, is the distance a body must fall freely under the force of gravity to acquire the velocity it possesses; or, in other words, the water in a flume has a certain velocity and to develop this velocity a certain amount of head is used. This amount of head must be deducted from the total fall to find the head left for friction, etc.

The loss due to velocity head may be very small in proportion to the friction loss on long flumes; but on short

flumes with high velocities, this loss may be proportionately very large.

The following table has been compiled to assist in the calculation of this loss. Example: Velocity equals 6.6 feet per second. From the table the velocity head is found to be 0.68 feet. Intermediate values of velocity may be interpolated. Example: For a velocity of 5.63, the velocity head loss would be 0.493 feet.

Velocity Head Loss

Table Showing Loss of Head (H_V) in Feet

Formula: $H_V = \frac{V^2}{2g}$

Vel. in Feet per Sec.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	.00	.00	.00	.00	.00	.01	.01	.01	.01	.02
1	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06
2	.06	.07	.08	.08	.09	.10	.11	.12	.12	.13
3	.14	.15	.16	.17	.18	.19	.20	.21	.22	.24
4	.25	.26	.27	.29	.30	.31	.33	.34	.36	.37
5	.39	.40	.42	.44	.45	.47	.49	.50	.52	.54
6	.56	.58	.60	.62	.63	.66	.68	.70	.72	.74
7	.76	.78	.80	.83	.85	.87	.90	.92	.94	.97
8	.99	1.01	1.04	1.07	1.09	1.12	1.15	1.17	1.20	1.23
9	1.26	1.28	1.31	1.34	1.37	1.40	1.43	1.46	1.49	1.52
10	1.55	1.58	1.62	1.65	1.68	1.72	1.75	1.78	1.81	1.85
11	1.88	1.92	1.95	1.98	2.02	2.06	2.09	2.13	2.16	2.20
12	2.24	2.27	2.31	2.35	2.39	2.43	2.47	2.50	2.54	2.58
13	2.63	2.67	2.71	2.75	2.79	2.83	2.87	2.92	2.96	3.00
14	3.04	3.09	3.13	3.17	3.22	3.26	3.31	3.36	3.40	3.45
15	3.50	3.54	3.59	3.64	3.68	3.73	3.78	3.83	3.88	3.93

Manning Formula: In 1890 Manning, an Irish engineer, derived a formula for computing open channel flow which offers practically all of the accuracy of the Kutter formula and possesses none of its cumbersomeness.

$$V = \frac{1.486\ R^{\frac{1}{6}}}{\text{“n”}} \sqrt{R\ S} = C\ \sqrt{R\ S}$$

In which V = Velocity in feet per second
R = Hydraulic radius
S = Slope
“n” = Coefficient of roughness (same “n” as Kutter)

To assist in the solution of the Manning formula, the following tables give the values of

$$C = \frac{1.486\ R^{\frac{1}{6}}}{\text{“n”}}$$

Values of C for Manning Formula:

“n” = Roughness Coef.	Hydraulic Radius R, in Feet															
	0.2	0.3	0.4	0.6	0.8	1.0	1.5	2.0	2.5	3.0	4.0	6.0	8.0	10.0	15	20
.010	112	120	126	136	142	148	159	167	173	178	187	200	210	218	234	246
.012	95	102	106	114	120	124	133	139	144	149	156	166	175	182	194	204
.013	88	94	98	105	110	115	123	129	133	137	144	153	161	167	179	188
.017	67	71	75	80	84	87	93	97	100	105	109	116	122	126	135	142
.020	57	61	64	68	72	74	80	84	86	89	93	100	104	108	116	122
.025	45	48	51	54	57	59	63	66	68	70	74	79	83	86	92	97
.030	38	40	42	45	48	50	53	55	57	59	62	66	69	72	77	81
.035	32	35	36	39	41	43	46	48	49	51	53	57	60	62	66	69

Values of “n”: The following table gives the approximate values of “n,” the roughness coefficient for various types of channel lining to be used in either the Kutter or Manning formula.

The value of “n,” used in calculating the flow of water through semi-circular wood flume on pages 203 to 213, was taken as 0.013, which is in keeping with the recommendations of F. C. Scobey, Senior Irrigation Engineer, Bureau of Agricultural Engineering, in Technical Bulletin No. 393.

Approximate Values of "n" for Manning or Kutter formula for Open Channel Flow.

Type of Channel Lining	Roughness Coefficient "n"
Glazed surfaces	.010
Planed timber, or wood flume	.013
Rough masonry	.017
Firm gravel	.020
Earth in ordinary condition	.025
Earth with stones, weeds, etc.	.030
Earth or gravel in bad condition	.035

How to Use Manning Formula: The following is an example of the use of the Manning formula in combination with the table on the opposite page. Assume water to be flowing 2 feet deep in a rough masonry box flume 4 feet wide laid to a grade of 1 foot per thousand or S = 0.001. The hydraulic radius equals $\frac{8}{8} = 1.0$. From the table the value of

$$\frac{1.486\ R^{\frac{1}{6}}}{\text{"n"}} = 87. \qquad \text{Then:}$$

$$V = 87\sqrt{RS} = 87\sqrt{(1)\ (0.001)} = 2.75$$

A table giving the square roots of decimal numbers will be found on page 263.

Flow Tables: The flow tables, pages 203 to 213, are a complete mathematical solution of Kutter's formula and give, at a glance, the complete solution of any problem involving the flow of water through semi-circular wood stave flumes.

Factor of Safety: It will be observed that in compiling these flow tables the area of the flume to the centerline only was used, which leaves the freeboard area as a factor of safety.

How to Use Flow Tables: Problem: Find size of flume.

Known: Length of flume	4000′
Total fall	4′
Quantity of water	80 c.f.s.

We will assume that the intake to the flume is properly designed so that the water will flow smoothly into the flume and there will be no loss of head occasioned by friction at the entrance. Also, the recovery in velocity head will not be considered as it is a refinement of calculation and may be neglected for all practical purposes.

The flume is 4000′ long and has a total fall of 4′ between intake and outlet; therefore, the fall per 1000′ will be 1′. Turning to the flow tables we look for some flume which will discharge approximately 80 c.f.s. with a fall of 1 foot per 1000. The 6½′ flume discharges 84.6 c.f.s. for a fall of 1 foot per 1000, which most nearly approaches the required conditions. The velocity required to discharge this quantity is 5.1 feet per second. To find the velocity head loss, turn to the table on page 199 and for a velocity of 5.1 this loss will be 0.40. This must be deducted from the total fall of 4 feet, leaving 3.6 feet of fall to overcome friction.

The fall per 1000′ now becomes, 3.6 divided by 4 = 0.9′. Now, looking again at the table, we find that for a fall of 0.9′ per 1000′ a 6½′ flume will discharge 80.1 cubic feet per second which is the required amount and thus this size of flume is the one desired.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	18″		20″		22″	
Area	0.88		1.09		1.32	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
0.10	.52	**.46**	.56	**.61**	.61	**.81**
0.15	.66	**.58**	.71	**.77**	.77	**1.02**
0.20	.77	**.68**	.84	**.92**	.90	**1.19**
0.25	.88	**.77**	.95	**1.04**	1.02	**1.35**
0.30	.97	**.85**	1.05	**1.14**	1.13	**1.49**
0.35	1.05	**.92**	1.14	**1.24**	1.23	**1.62**
0.40	1.14	**1.00**	1.23	**1.34**	1.31	**1.73**
0.45	1.21	**1.06**	1.31	**1.43**	1.40	**1.85**
0.50	1.28	**1.13**	1.39	**1.52**	1.48	**1.95**
0.55	1.35	**1.19**	1.45	**1.58**	1.56	**2.06**
0.60	1.41	**1.24**	1.52	**1.66**	1.63	**2.15**
0.65	1.46	**1.28**	1.59	**1.73**	1.70	**2.24**
0.70	1.52	**1.34**	1.65	**1.80**	1.76	**2.32**
0.75	1.58	**1.39**	1.71	**1.86**	1.83	**2.42**
0.80	1.63	**1.43**	1.77	**1.93**	1.89	**2.49**
0.85	1.69	**1.49**	1.82	**1.98**	1.95	**2.57**
0.90	1.74	**1.53**	1.88	**2.05**	2.01	**2.65**
0.95	1.79	**1.58**	1.93	**2.10**	2.07	**2.73**
1.00	1.84	**1.62**	1.98	**2.16**	2.12	**2.80**
1.1	1.92	**1.69**	2.08	**2.27**	2.22	**2.93**
1.2	2.01	**1.77**	2.18	**2.38**	2.33	**3.08**
1.3	2.10	**1.85**	2.27	**2.47**	2.43	**3.21**
1.4	2.18	**1.92**	2.36	**2.57**	2.52	**3.33**
1.5	2.25	**1.98**	2.44	**2.66**	2.61	**3.45**
1.6	2.33	**2.05**	2.52	**2.75**	2.70	**3.56**
1.7	2.41	**2.12**	2.60	**2.83**	2.78	**3.67**
1.8	2.48	**2.18**	2.68	**2.92**	2.86	**3.78**
1.9	2.55	**2.24**	2.75	**3.00**	2.95	**3.89**
2.0	2.61	**2.30**	2.83	**3.08**	3.03	**4.00**
2.5	2.92	**2.57**	3.15	**3.43**	3.38	**4.46**
3.0	3.20	**2.82**	3.47	**3.78**	3.71	**4.90**
3.5	3.46	**3.04**	3.75	**4.09**	4.01	**5.29**
4.0	3.71	**3.26**	4.02	**4.38**	4.29	**5.66**
4.5	3.94	**3.47**	4.26	**4.64**	4.55	**6.01**
5.0	4.16	**3.66**	4.49	**4.89**	4.81	**6.35**

For a description of the construction of "National Quality" semi-circular wood stave flumes, see pages 111 *to* 117.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	24″		26″		28″	
Area	1.57		1.84		2.14	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	.65	**1.02**	.69	**1.27**	.73	**1.56**
.15	.82	**1.29**	.87	**1.60**	.92	**1.97**
.20	.96	**1.51**	1.02	**1.88**	1.08	**2.31**
.25	1.09	**1.71**	1.16	**2.13**	1.23	**2.63**
.30	1.21	**1.90**	1.28	**2.36**	1.35	**2.89**
.35	1.30	**2.04**	1.39	**2.56**	1.47	**3.15**
.40	1.40	**2.20**	1.48	**2.72**	1.57	**3.36**
.45	1.49	**2.34**	1.58	**2.91**	1.67	**3.57**
.50	1.58	**2.48**	1.68	**3.09**	1.77	**3.79**
.55	1.66	**2.61**	1.76	**3.24**	1.86	**3.98**
.60	1.73	**2.72**	1.84	**3.39**	1.94	**4.15**
.65	1.81	**2.84**	1.92	**3.53**	2.02	**4.32**
.70	1.88	**2.95**	2.00	**3.68**	2.11	**4.52**
.75	1.95	**3.06**	2.07	**3.81**	2.18	**4.67**
.80	2.02	**3.17**	2.13	**3.92**	2.26	**4.84**
.85	2.08	**3.27**	2.21	**4.07**	2.33	**4.99**
.90	2.14	**3.36**	2.27	**4.18**	2.40	**5.14**
.95	2.20	**3.45**	2.33	**4.29**	2.46	**5.26**
1.0	2.26	**3.55**	2.40	**4.42**	2.52	**5.39**
1.1	2.38	**3.74**	2.51	**4.62**	2.65	**5.67**
1.2	2.48	**3.89**	2.63	**4.84**	2.78	**5.95**
1.3	2.59	**4.07**	2.74	**5.04**	2.89	**6.18**
1.4	2.69	**4.22**	2.85	**5.24**	3.01	**6.44**
1.5	2.78	**4.36**	2.94	**5.41**	3.11	**6.66**
1.6	2.88	**4.52**	3.04	**5.59**	3.21	**6.87**
1.7	2.97	**4.66**	3.13	**5.76**	3.31	**7.08**
1.8	3.05	**4.79**	3.23	**5.94**	3.41	**7.30**
1.9	3.13	**4.91**	3.32	**6.11**	3.51	**7.51**
2.0	3.22	**5.06**	3.41	**6.27**	3.59	**7.68**
2.5	3.60	**5.65**	3.81	**7.01**	4.03	**8.62**
3.0	3.95	**6.20**	4.18	**7.69**	4.41	**9.44**
3.5	4.27	**6.70**	4.53	**8.34**	4.77	**10.2**
4.0	4.56	**7.16**	4.84	**8.91**	5.10	**10.9**
4.5	4.84	**7.60**	5.13	**9.44**	5.41	**11.6**
5.0	5.11	**8.02**	5.41	**9.95**	5.71	**12.2**

Our Engineering Department will be pleased to assist you in the design of a semi-circular flume to meet your particular requirements.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	2 ½′		3′		3 ½′	
Area	2.46		3.54		4.81	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	.77	**1.89**	.89	**3.15**	.99	**4.76**
.15	.97	**2.38**	1.11	**3.93**	1.25	**6.01**
.20	1.14	**2.80**	1.31	**4.64**	1.45	**6.97**
.25	1.28	**3.15**	1.47	**5.20**	1.64	**7.89**
.30	1.42	**3.49**	1.62	**5.73**	1.81	**8.71**
.35	1.54	**3.79**	1.75	**6.19**	1.96	**9.43**
.40	1.65	**4.06**	1.88	**6.66**	2.10	**10.1**
.45	1.76	**4.33**	2.00	**7.08**	2.23	**10.7**
.50	1.86	**4.58**	2.12	**7.50**	2.35	**11.3**
.55	1.95	**4.80**	2.22	**7.86**	2.47	**11.9**
.60	2.04	**5.02**	2.32	**8.21**	2.59	**12.5**
.65	2.13	**5.24**	2.42	**8.57**	2.69	**12.9**
.70	2.21	**5.44**	2.51	**8.89**	2.81	**13.5**
.75	2.29	**5.63**	2.61	**9.24**	2.90	**13.9**
.80	2.37	**5.83**	2.69	**9.52**	3.00	**14.4**
.85	2.44	**6.00**	2.78	**9.84**	3.10	**14.9**
.90	2.51	**6.17**	2.86	**10.1**	3.18	**15.3**
.95	2.59	**6.37**	2.94	**10.4**	3.27	**15.7**
1.0	2.65	**6.52**	3.02	**10.7**	3.36	**16.2**
1.1	2.78	**6.84**	3.17	**11.2**	3.52	**16.9**
1.2	2.91	**7.16**	3.31	**11.7**	3.69	**17.7**
1.3	3.03	**7.45**	3.45	**12.2**	3.84	**18.5**
1.4	3.15	**7.75**	3.58	**12.7**	3.99	**19.2**
1.5	3.26	**8.02**	3.71	**13.1**	4.13	**19.9**
1.6	3.37	**8.29**	3.83	**13.6**	4.26	**20.5**
1.7	3.48	**8.56**	3.95	**14.0**	4.40	**21.2**
1.8	3.58	**8.81**	4.08	**14.4**	4.53	**21.8**
1.9	3.68	**9.05**	4.18	**14.8**	4.65	**22.4**
2.0	3.78	**9.3**	4.29	**15.2**	4.77	**22.9**
2.5	4.22	**10.4**	4.80	**17.0**	5.34	**25.7**
3.0	4.64	**11.4**	5.26	**18.6**	5.85	**28.1**
3.5	5.01	**12.3**	5.69	**20.1**	6.32	**30.4**
4.0	5.35	**13.2**	6.09	**21.6**	6.77	**32.6**
4.5	5.68	**14.0**	6.46	**22.9**	7.18	**34.5**
5.0	6.00	**14.8**	6.80	**24.1**	7.56	**36.4**

"National Quality" semi-circular wood flumes will carry more water for a given diameter than any other type of flume.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	4′		4 ½′		5′	
Area	6.28		7.95		9.82	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	1.10	**6.9**	1.20	**9.5**	1.29	**12.7**
.15	1.38	**8.7**	1.50	**11.9**	1.61	**15.8**
.20	1.60	**10.0**	1.74	**13.8**	1.87	**18.4**
.25	1.80	**11.3**	1.96	**15.6**	2.11	**20.7**
.30	1.98	**12.4**	2.16	**17.2**	2.32	**22.8**
.35	2.15	**13.5**	2.33	**18.5**	2.51	**24.6**
.40	2.30	**14.4**	2.50	**19.9**	2.69	**26.4**
.45	2.45	**15.4**	2.63	**20.9**	2.85	**28.0**
.50	2.59	**16.3**	2.80	**22.3**	3.01	**29.6**
.55	2.72	**17.1**	2.95	**23.5**	3.16	**31.0**
.60	2.83	**17.8**	3.08	**24.5**	3.31	**32.5**
.65	2.96	**18.6**	3.20	**25.4**	3.44	**33.8**
.70	3.08	**19.3**	3.34	**26.6**	3.58	**35.2**
.75	3.18	**20.0**	3.44	**27.3**	3.70	**36.3**
.80	3.29	**20.7**	3.56	**28.3**	3.83	**37.6**
.85	3.40	**21.4**	3.67	**29.2**	3.95	**38.8**
.90	3.49	**21.9**	3.78	**30.1**	4.06	**39.9**
.95	3.59	**22.5**	3.89	**30.9**	4.18	**41.0**
1.0	3.68	**23.1**	3.99	**31.7**	4.29	**42.1**
1.1	3.87	**24.3**	4.19	**33.3**	4.50	**44.2**
1.2	4.04	**25.4**	4.37	**34.7**	4.70	**46.2**
1.3	4.21	**26.4**	4.55	**36.2**	4.89	**48.0**
1.4	4.37	**27.4**	4.73	**37.6**	5.08	**49.9**
1.5	4.52	**28.4**	4.90	**39.0**	5.26	**51.7**
1.6	4.67	**29.3**	5.06	**40.2**	5.43	**53.3**
1.7	4.81	**30.2**	5.21	**41.4**	5.60	**55.0**
1.8	4.96	**31.1**	5.37	**42.7**	5.76	**56.6**
1.9	5.10	**32.0**	5.51	**43.8**	5.92	**58.1**
2.0	5.22	**32.8**	5.66	**45.0**	6.08	**59.7**
2.5	5.85	**36.7**	6.33	**50.3**	6.80	**66.8**
3.0	6.42	**40.3**	6.94	**55.2**	7.45	**73.2**
3.5	6.94	**43.6**	7.51	**59.7**	8.05	**79.1**
4.0	7.42	**46.6**	8.02	**63.8**	8.61	**84.6**
4.5	7.86	**49.4**	8.51	**67.7**	9.14	**89.8**
5.0	8.29	**52.1**	8.97	**71.3**	9.64	**94.7**

These flow tables are very conservative as they are based on the area up to the diameter line, leaving the freeboard area as a factor of safety.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	5 ½′		6′		6 ½′	
Area	11.88		14.14		16.59	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	1.38	**16.4**	1.47	**20.8**	1.55	**25.7**
.15	1.72	**20.4**	1.83	**25.9**	1.93	**32.0**
.20	2.00	**23.8**	2.12	**30.0**	2.24	**37.2**
.25	2.24	**26.6**	2.39	**33.8**	2.52	**41.8**
.30	2.47	**29.3**	2.62	**37.0**	2.77	**46.0**
.35	2.67	**31.7**	2.84	**40.2**	2.99	**49.6**
.40	2.87	**34.1**	3.04	**43.0**	3.20	**53.1**
.45	3.04	**36.1**	3.23	**45.7**	3.40	**56.4**
.50	3.21	**38.1**	3.41	**48.2**	3.59	**59.6**
.55	3.37	**40.0**	3.57	**50.5**	3.77	**62.5**
.60	3.52	**41.8**	3.74	**52.9**	3.93	**65.2**
.65	3.67	**43.6**	3.89	**55.0**	4.10	**68.0**
.70	3.81	**45.3**	4.04	**57.1**	4.27	**70.8**
.75	3.94	**46.8**	4.18	**59.1**	4.41	**73.2**
.80	4.08	**48.5**	4.32	**61.1**	4.56	**75.7**
.85	4.20	**49.9**	4.46	**63.1**	4.69	**77.8**
.90	4.33	**51.4**	4.60	**65.0**	4.83	**80.1**
.95	4.44	**52.7**	4.71	**66.6**	4.95	**82.1**
1.0	4.57	**54.3**	4.83	**68.3**	5.10	**84.6**
1.1	4.79	**56.9**	5.08	**71.8**	5.35	**88.8**
1.2	5.00	**59.4**	5.30	**74.9**	5.59	**92.7**
1.3	5.21	**61.9**	5.53	**78.2**	5.81	**96.4**
1.4	5.41	**64.3**	5.73	**81.0**	6.04	**100.**
1.5	5.59	**66.4**	5.93	**83.9**	6.26	**104.**
1.6	5.79	**68.8**	6.13	**86.7**	6.46	**107.**
1.7	5.97	**70.9**	6.32	**89.4**	6.65	**110.**
1.8	6.13	**72.8**	6.51	**92.1**	6.86	**114.**
1.9	6.30	**74.8**	6.69	**94.6**	7.04	**117.**
2.0	6.47	**76.9**	6.86	**97.0**	7.22	**120.**
2.5	7.24	**86.0**	7.67	**108.**	8.07	**134.**
3.0	7.93	**94.2**	8.41	**119.**	8.85	**147.**
3.5	8.57	**102.**	9.09	**129.**	9.57	**159.**
4.0	9.17	**109.**	9.72	**137.**	10.2	**169.**
4.5	9.73	**116.**	10.3	**146.**	10.9	**180.**
5.0	10.2	**121.**	10.9	**154.**	11.4	**189.**

There is no longitudinal contraction or expansion in "National Quality" semi-circular flumes; therefore, no expansion joints are required.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	7′		7 ½′		8′	
Area	19.24		22.09		25.14	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	1.64	**31.6**	1.72	**38.0**	1.80	**45.3**
.15	2.03	**39.1**	2.13	**47.1**	2.22	**55.8**
.20	2.36	**45.4**	2.47	**54.6**	2.58	**64.9**
.25	2.65	**51.0**	2.78	**61.4**	2.90	**72.9**
.30	2.90	**55.8**	3.04	**67.2**	3.17	**79.7**
.35	3.15	**60.6**	3.29	**72.7**	3.44	**86.5**
.40	3.37	**64.8**	3.52	**77.8**	3.68	**92.5**
.45	3.58	**68.9**	3.73	**82.4**	3.90	**98.1**
.50	3.77	**72.5**	3.94	**87.0**	4.11	**103.**
.55	3.95	**76.0**	4.13	**91.2**	4.32	**109.**
.60	4.14	**79.7**	4.32	**95.4**	4.50	**113.**
.65	4.30	**82.7**	4.50	**99.4**	4.70	**118.**
.70	4.47	**86.0**	4.67	**103.**	4.87	**122.**
.75	4.63	**89.1**	4.85	**107.**	5.04	**127.**
.80	4.78	**92.0**	5.00	**110.**	5.21	**131.**
.85	4.94	**95.0**	5.15	**114.**	5.37	**135.**
.90	5.08	**97.7**	5.31	**117.**	5.53	**139.**
.95	5.22	**100.**	5.45	**120.**	5.68	**143.**
1.0	5.35	**103.**	5.61	**124.**	5.83	**147.**
1.1	5.62	**108.**	5.87	**130.**	6.12	**154.**
1.2	5.87	**113.**	6.13	**135.**	6.40	**161.**
1.3	6.11	**118.**	6.39	**141.**	6.65	**167.**
1.4	6.34	**122.**	6.64	**147.**	6.91	**174.**
1.5	6.56	**126.**	6.86	**152.**	7.15	**180.**
1.6	6.78	**130.**	7.09	**157.**	7.39	**186.**
1.7	6.99	**134.**	7.31	**161.**	7.61	**191.**
1.8	7.21	**139.**	7.52	**166.**	7.84	**197.**
1.9	7.40	**142.**	7.73	**171.**	8.05	**202.**
2.0	7.59	**146.**	7.92	**175.**	8.26	**208.**
2.5	8.48	**163.**	8.87	**196.**	9.24	**232.**
3.0	9.30	**179.**	9.71	**214.**	10.1	**254.**
3.5	10.1	**194.**	10.5	**232.**	10.9	**274.**
4.0	10.8	**208.**	11.2	**247.**	11.7	**294.**
4.5	11.4	**219.**	11.9	**263.**	12.4	**312.**
5.0	12.0	**231.**	12.6	**278.**	13.1	**329.**

"National Quality" wood stave flumes are always free from rust, scale, and corrosion; therefore, they always maintain their original capacity.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	8 ½′		9′		9 ½′	
Area	28.37		31.81		35.44	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	1.88	**53.3**	1.95	**62.0**	2.03	**71.9**
.15	2.33	**66.1**	2.41	**76.7**	2.50	**88.6**
.20	2.69	**76.3**	2.79	**88.7**	2.90	**103.**
.25	3.01	**85.4**	3.12	**99.2**	3.25	**115.**
.30	3.31	**93.9**	3.44	**109.**	3.56	**126.**
.35	3.58	**102.**	3.73	**119.**	3.84	**136.**
.40	3.83	**109.**	3.96	**126.**	4.11	**146.**
.45	4.05	**115.**	4.20	**134.**	4.37	**155.**
.50	4.28	**121.**	4.44	**141.**	4.61	**163.**
.55	4.49	**127.**	4.66	**148.**	4.84	**172.**
.60	4.69	**133.**	4.86	**155.**	5.05	**179.**
.65	4.89	**139.**	5.05	**161.**	5.24	**186.**
.70	5.08	**144.**	5.26	**167.**	5.44	**193.**
.75	5.25	**149.**	5.44	**173.**	5.64	**200.**
.80	5.42	**154.**	5.62	**179.**	5.83	**207.**
.85	5.59	**159.**	5.79	**184.**	5.98	**212.**
.90	5.75	**163.**	5.98	**190.**	6.19	**219.**
.95	5.91	**168.**	6.14	**195.**	6.36	**225.**
1.0	6.07	**172.**	6.28	**200.**	6.53	**231.**
1.1	6.37	**181.**	6.60	**210.**	6.84	**242.**
1.2	6.65	**189.**	6.90	**219.**	7.15	**253.**
1.3	6.93	**197.**	7.17	**228.**	7.44	**264.**
1.4	7.18	**204.**	7.44	**237.**	7.73	**274.**
1.5	7.43	**211.**	7.70	**245.**	7.99	**283.**
1.6	7.68	**218.**	7.96	**253.**	8.25	**292.**
1.7	7.92	**225.**	8.21	**261.**	8.52	**302.**
1.8	8.15	**231.**	8.44	**268.**	8.76	**310.**
1.9	8.37	**237.**	8.67	**276.**	9.00	**319.**
2.0	8.57	**243.**	8.90	**283.**	9.23	**327.**
2.5	9.61	**273.**	9.95	**317.**	10.3	**365.**
3.0	10.5	**298.**	10.9	**347.**	11.3	**400.**
3.5	11.4	**323.**	11.8	**375.**	12.2	**432.**
4.0	12.2	**346.**	12.6	**401.**	13.1	**464.**
4.5	12.9	**366.**	13.4	**426.**	13.9	**493.**
5.0	13.6	**386.**	14.1	**449.**	14.6	**517.**

"National Quality" creosoted Douglas Fir semi-circular flumes make a permanent installation—no painting required.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	10′		11′		12′	
Area	39.27		47.52		56.55	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	2.10	**83.**	2.25	**107.**	2.37	**134.**
.15	2.59	**102.**	2.76	**131.**	2.92	**165.**
.20	3.00	**118.**	3.20	**152.**	3.37	**191.**
.25	3.35	**132.**	3.57	**170.**	3.77	**213.**
.30	3.68	**145.**	3.91	**186.**	4.13	**234.**
.35	3.98	**156.**	4.22	**201.**	4.46	**252.**
.40	4.24	**167.**	4.52	**215.**	4.76	**269.**
.45	4.51	**177.**	4.80	**228.**	5.05	**286.**
.50	4.76	**187.**	5.06	**240.**	5.33	**301.**
.55	4.99	**196.**	5.31	**252.**	5.59	**316.**
.60	5.21	**205.**	5.54	**263.**	5.84	**330.**
.65	5.42	**213.**	5.77	**274.**	6.09	**344.**
.70	5.63	**221.**	5.99	**285.**	6.31	**357.**
.75	5.83	**229.**	6.19	**294.**	6.53	**369.**
.80	6.02	**236.**	6.40	**304.**	6.75	**382.**
.85	6.21	**244.**	6.61	**314.**	6.96	**394.**
.90	6.38	**251.**	6.79	**323.**	7.17	**405.**
.95	6.60	**259.**	6.97	**331.**	7.36	**416.**
1.0	6.74	**265.**	7.15	**340.**	7.55	**427.**
1.1	7.06	**277.**	7.51	**357.**	7.92	**448.**
1.2	7.37	**289.**	7.84	**373.**	8.27	**468.**
1.3	7.68	**302.**	8.16	**388.**	8.62	**487.**
1.4	7.97	**313.**	8.46	**402.**	8.93	**505.**
1.5	8.24	**324.**	8.78	**417.**	9.25	**523.**
1.6	8.53	**335.**	9.05	**430.**	9.56	**541.**
1.7	8.78	**345.**	9.34	**444.**	9.85	**557.**
1.8	9.05	**355.**	9.61	**457.**	10.1	**571.**
1.9	9.29	**365.**	9.87	**469.**	10.4	**588.**
2.0	9.52	**374.**	10.1	**480.**	10.7	**605.**
2.5	10.7	**420.**	11.3	**537.**	11.9	**673.**
3.0	11.7	**459.**	12.4	**589.**	13.1	**741.**
3.5	12.6	**495.**	13.4	**637.**	14.1	**797.**
4.0	13.5	**530.**	14.3	**680.**		
4.5	14.4	**565.**				

We are prepared to contract for flumes erected complete, ready for use, or furnish a skilled mechanic to supervise the erection by local labor.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second.

(n = 0.013)

Diameter	13′		14′		15′	
Area	66.37		76.97		88.36	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	2.51	**167.**	2.64	**203.**	2.76	**244.**
.15	3.08	**204.**	3.23	**249.**	3.37	**298.**
.20	3.55	**236.**	3.73	**287.**	3.89	**344.**
.25	3.97	**263.**	4.17	**321.**	4.34	**383.**
.30	4.34	**288.**	4.56	**351.**	4.75	**420.**
.35	4.69	**311.**	4.94	**380.**	5.13	**453.**
.40	5.03	**334.**	5.26	**405.**	5.48	**484.**
.45	5.32	**353.**	5.59	**430.**	5.82	**514.**
.50	5.62	**373.**	5.88	**453.**	6.15	**543.**
.55	5.89	**391.**	6.18	**476.**	6.43	**568.**
.60	6.15	**408.**	6.44	**496.**	6.72	**594.**
.65	6.39	**424.**	6.71	**516.**	7.00	**619.**
.70	6.64	**441.**	6.96	**536.**	7.26	**641.**
.75	6.88	**457.**	7.21	**555.**	7.50	**663.**
.80	7.10	**471.**	7.44	**573.**	7.76	**686.**
.85	7.31	**485.**	7.68	**591.**	8.00	**707.**
.90	7.53	**500.**	7.89	**607.**	8.23	**727.**
.95	7.74	**514.**	8.12	**625.**	8.45	**747.**
1.0	7.93	**527.**	8.32	**640.**	8.66	**765.**
1.1	8.32	**552.**	8.72	**671.**	9.10	**804.**
1.2	8.69	**577.**	9.11	**701.**	9.49	**839.**
1.3	9.05	**601.**	9.49	**730.**	9.90	**875.**
1.4	9.40	**624.**	9.84	**757.**	10.3	**910.**
1.5	9.73	**646.**	10.2	**785.**	10.6	**937.**
1.6	10.0	**664.**	10.5	**808.**	11.0	**972.**
1.7	10.4	**690.**	10.8	**831.**	11.3	**998.**
1.8	10.7	**710.**	11.2	**862.**	11.6	**1030.**
1.9	10.9	**723.**	11.5	**885.**	11.9	**1050.**
2.0	11.2	**743.**	11.8	**908.**	12.3	**1090.**
2.5	12.6	**836.**	13.1	**1010.**	13.7	**1210.**
3.0	13.7	**909.**	14.3	**1100.**	15.0	**1330.**
3.5	14.9	**989.**				

"National Quality" semi-circular wood flumes can be built to the contour of the ground without the use of special fittings. They are very efficient as there are no sharp angles to cause friction loss.

Flow of Water in Semi-Circular Wood Flume

Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	16′		17′		18′	
Area	100.53		113.49		127.24	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	2.88	**290.**	2.99	**339.**	3.11	**396.**
.15	3.51	**353.**	3.66	**415.**	3.79	**482.**
.20	4.04	**406.**	4.21	**478.**	4.37	**556.**
.25	4.52	**454.**	4.70	**533.**	4.88	**621.**
.30	4.94	**497.**	5.14	**583.**	5.33	**678.**
.35	5.34	**537.**	5.55	**630.**	5.76	**733.**
.40	5.71	**574.**	5.93	**673.**	6.14	**781.**
.45	6.05	**608.**	6.29	**714.**	6.53	**831.**
.50	6.38	**641.**	6.64	**754.**	6.86	**873.**
.55	6.69	**673.**	6.96	**790.**	7.21	**917.**
.60	6.99	**703.**	7.25	**823.**	7.53	**958.**
.65	7.28	**732.**	7.54	**856.**	7.83	**996.**
.70	7.55	**759.**	7.85	**891.**	8.12	**1030.**
.75	7.81	**785.**	8.11	**920.**	8.40	**1070.**
.80	8.07	**811.**	8.37	**950.**	8.68	**1100.**
.85	8.31	**835.**	8.63	**979.**	8.95	**1140.**
.90	8.55	**860.**	8.88	**1010.**	9.20	**1170.**
.95	8.78	**883.**	9.13	**1040.**	9.46	**1200.**
1.0	9.02	**907.**	9.36	**1060.**	9.70	**1230.**
1.1	9.45	**950.**	9.82	**1110.**	10.2	**1300.**
1.2	9.88	**993.**	10.3	**1170.**	10.6	**1350.**
1.3	10.3	**1040.**	10.7	**1210.**	11.1	**1410.**
1.4	10.7	**1080.**	11.1	**1260.**	11.5	**1460.**
1.5	11.0	**1110.**	11.5	**1310.**	11.9	**1510.**
1.6	11.4	**1150.**	11.8	**1340.**	12.3	**1560.**
1.7	11.8	**1190.**	12.2	**1380.**	12.6	**1600.**
1.8	12.1	**1220.**	12.6	**1430.**	13.0	**1650.**
1.9	12.4	**1250.**	12.9	**1460.**	13.4	**1700.**
2.0	12.7	**1280.**	13.2	**1500.**	13.7	**1740.**
2.5	14.2	**1430.**				

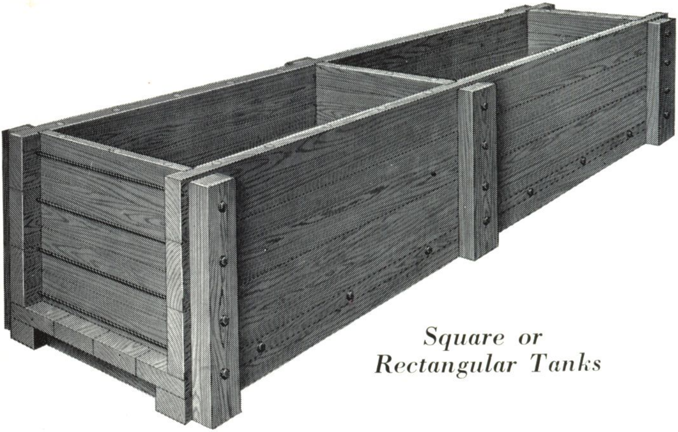
In many cases as much as 40% of the water is lost between the intake and point of use through seepage loss in ditches or canals. This loss is being prevented by many irrigation districts through the use of "National Quality" wood stave flume.

Flow of Water in Semi-Circular Wood Flume

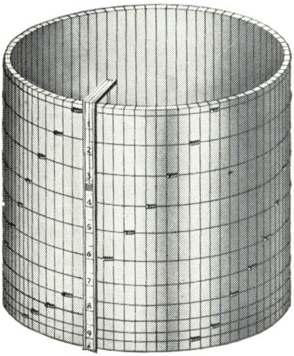
Areas in Square Feet Calculated to Center Line.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second. (n = 0.013)

Diameter	19′		20′		24′	
Area	141.77		157.08		226.19	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
.10	3.21	**455.**	3.34	**525.**	3.74	**846.**
.15	3.91	**554.**	4.05	**636.**	4.54	**1030.**
.20	4.50	**638.**	4.66	**732.**	5.20	**1180.**
.25	5.03	**713.**	5.21	**818.**	5.81	**1310.**
.30	5.51	**781.**	5.68	**892.**	6.35	**1440.**
.35	5.93	**841.**	6.13	**963.**	6.85	**1550.**
.40	6.34	**899.**	6.55	**1030.**	7.32	**1660.**
.45	6.73	**954.**	6.95	**1090.**	7.76	**1760.**
.50	7.10	**1010.**	7.32	**1150.**	8.17	**1850.**
.55	7.42	**1050.**	7.67	**1200.**	8.57	**1940.**
.60	7.75	**1100.**	8.02	**1260.**	8.93	**2020.**
.65	8.07	**1140.**	8.34	**1310.**	9.31	**2110.**
.70	8.37	**1190.**	8.66	**1360.**	9.65	**2180.**
.75	8.67	**1230.**	8.95	**1410.**	9.98	**2260.**
.80	8.94	**1270.**	9.25	**1450.**	10.3	**2330.**
.85	9.23	**1310.**	9.53	**1500.**	10.6	**2400.**
.90	9.49	**1350.**	9.81	**1540.**	10.9	**2470.**
.95	9.75	**1380.**	10.1	**1590.**	11.2	**2530.**
1.0	10.0	**1420.**	10.3	**1620.**	11.5	**2600.**
1.1	10.5	**1490.**	10.8	**1700.**	12.1	**2740.**
1.2	11.0	**1560.**	11.3	**1780.**	12.6	**2850.**
1.3	11.4	**1620.**	11.8	**1850.**	13.1	**2960.**
1.4	11.8	**1670.**	12.2	**1920.**	13.6	**3080.**
1.5	12.2	**1730.**	12.6	**1980.**	14.1	**3190.**
1.6	12.6	**1790.**	13.1	**2060.**	14.6	**3300.**
1.7	13.0	**1840.**	13.5	**2110.**	15.0	**3390.**
1.8	13.4	**1900.**	13.9	**2180.**		
1.9	13.8	**1960.**	14.2	**2230.**		
2.0	14.1	**2000.**				

The maintenance cost of "National Quality" wood stave flume is less than that required for any other type of flumes or ditches. "National Quality" creosoted Douglas Fir flume is truly an economical and permanent installation.

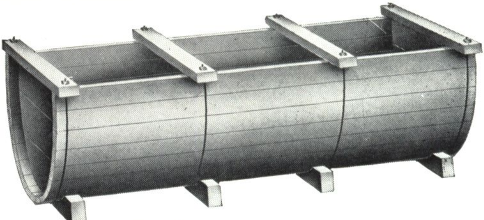


Square or Rectangular Tanks



Water Tanks

LONG LIFE
. . . LOW COST
. . . ADAPTABILITY



Half-Round Tanks

"National Quality"

WOOD TANKS

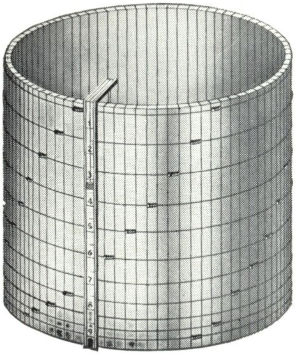
Send for a copy of our Wood Tank Catalog. It contains many pages of valuable information on the design, erection, and use of wood tanks for all purposes.

TECHNICAL SERVICE

Let us assist you in the design of wood tanks that will economically meet your requirements. An abundance of designs and information accumulated over a period of forty years will be at your disposal if you merely place your problems before our Engineering Department.

ERECTION

"National Quality" tanks are shipped knocked down. Accompanying each shipment is a complete set of illustrated instructions showing exactly how to erect the tanks. On large installations we are prepared to contract for the tanks erected complete, ready for use; or we can furnish a skilled tank man to supervise the erection of the tanks by local labor.



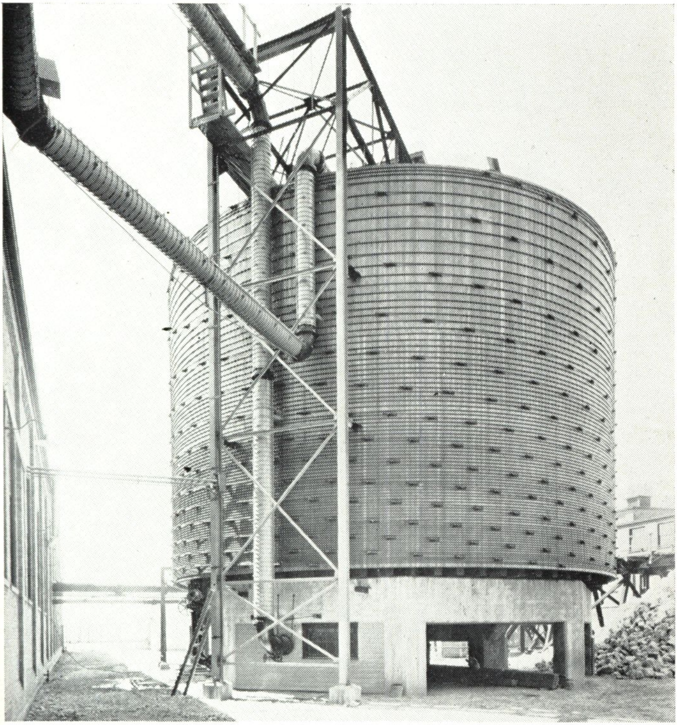
WATER TANKS

"National Quality" wood tanks are shipped knocked down with complete instructions for erection. Send for our wood tank catalog which contains information on wood tanks for all purposes.

Price List of Plain Water Tanks

Capacity, Gals.	Diameter		Height Ft.	Approx. Weight Lbs.	Thickness Inches	List Price
	Ft.	In.				
500	5	1	4	438	2	$ 32.00
800	6	0	5	644	2	43.00
1,000	6	6	5	729	2	50.00
1,500	8	0	5	936	2	61.00
2,000	8	0	6	1,068	2	70.00
2,500	8	0	7	1,200	2	78.00
3,000	9	0	7	1,350	2	88.00
4,000	9	0	9	1,646	2	107.00
5,000	10	0	9	1,860	2	121.00
6,000	12	0	8	2,132	2	139.00
7,000	12	0	9	2,330	2	152.00
8,000	12	0	10	2,528	2	165.00
10,000	13	8	10	2,963	2	195.00
10,000	13	8	10	4,730	3	274.00
12,000	14	0	12	5,621	3	323.00
15,000	16	0	12	6,588	3	378.00
20,000	18	0	12	7,811	3	453.00
25,000	18	0	14	8,925	3	523.00
30,000	20	0	14	10,214	3	598.00
40,000	23	0	14	12,375	3	730.00
50,000	24	0	16	14,818	3	886.00
60,000	26	0	16	16,527	3	990.00
75,000	29	0	16	19,294	3	1,165.00
100,000	30	0	20	24,980	3	1,546.00

All List Prices Subject to Discount.

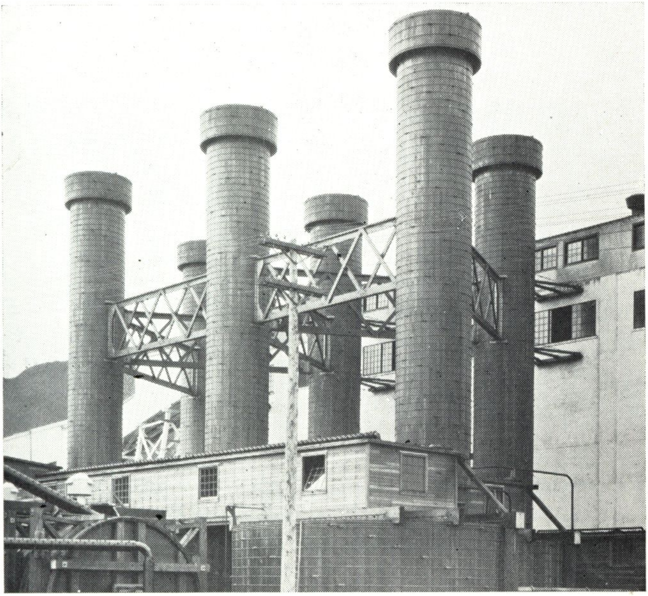


This "National Quality" Douglas Fir Tank is 50′0″ inside diameter by 32′0″ deep inside and has a capacity of about 471,000 gallons.

Tanks of this size are usually designed to meet a particular requirement. If you have a problem involving special tanks, let our Engineering Department help you work out plans and specifications.

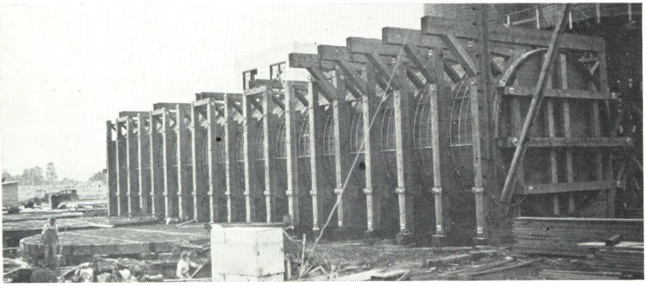
125,000 *gallon "National Quality" water tank on a* 50-*foot wood tower.*

If you have a tank and tower problem, let our Engineering Department help you work out your plans and specifications.

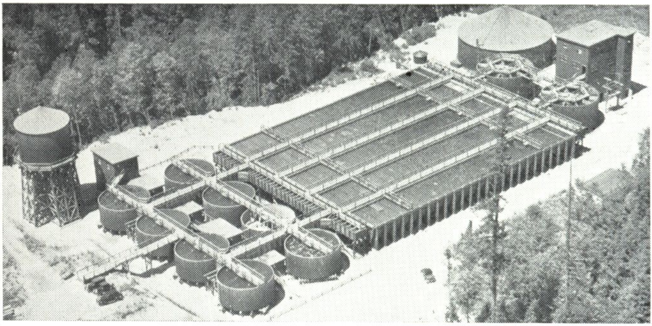


"National Quality" Stacks

Our Engineering Department will be glad to work with you in the design of stacks to meet your requirements.



"National Quality" Horizontal Tank 20 feet inside diameter by 120 feet long inside

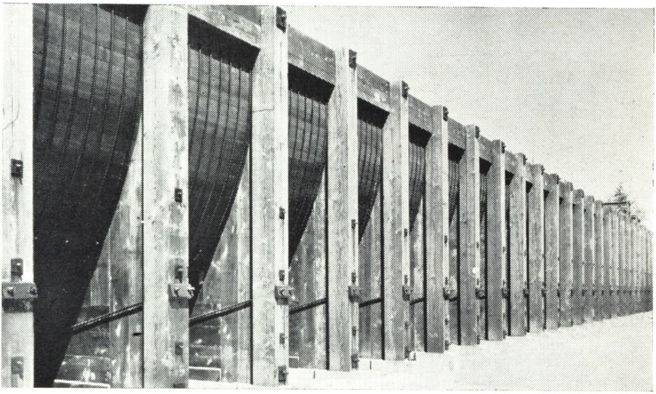


Designed by O. C. Schoenwerk

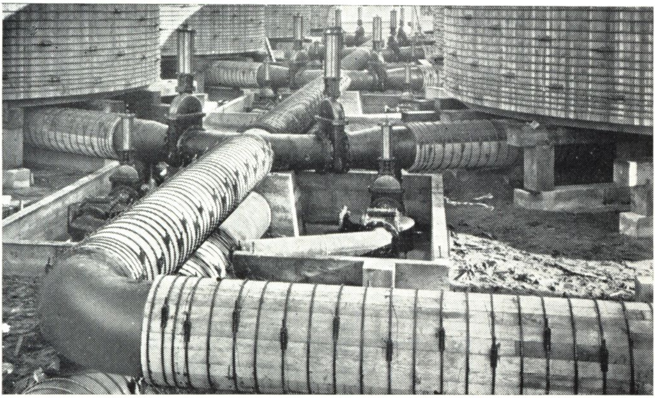
18,000,000 *gallon per day Water Purification Plant constructed entirely of "National Quality" Wood Tanks and Wood Pipe.*

"National Quality" Wood Tanks and Wood Pipe made possible the construction of this modern water purification plant. A plant of this type can be made in units of any capacity. A sufficient number of units can be installed to meet present requirements and additional units added from time to time to take care of increased demand for pure, clean water. With this new type of construction, it is unnecessary to make an immediate large investment to take care of future requirements.

"National Quality" Wood Tanks and Wood Pipe also have a distinct application in the construction of sewage treatment plants.

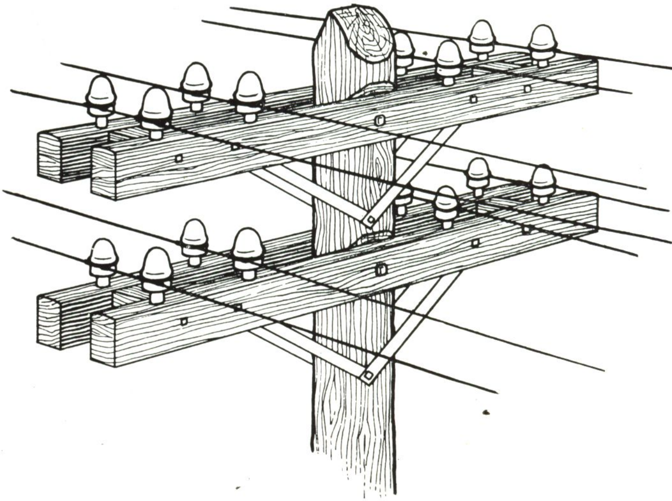


"National Quality" tanks 24 feet diameter by 14 feet deep by 172 feet long used as settling basins in the filter plant illustrated on opposite page.
Patent No. 2,127,799



"National Quality" filter tanks with continuous wood stave pipe and steel fittings.

STANDARD CROSSARMS



We are prepared to furnish Douglas Fir Crossarms for Power Lines, Telephone and Telegraph Lines, manufactured in accordance with any specifications.

"National Quality" Crossarms are made with the same scrupulous care and workmanship as "National Quality" wood tanks and pipe. They meet the exacting requirements imposed by the principal users of crossarms throughout the country.

They are furnished untreated, creosote pressure treated, creosote dipped, carbolineum dipped, or painted with highest quality mineral paint or lead and oil, as desired.

Prices on application.

Conversion Factors

MULTIPLY	BY	TO OBTAIN
acres	43560.	square feet
"	4047.	square meters
"	.001562	square miles
"	4840.	square yards
acre-feet	43560.	cubic-feet
" "	325900.	gallons
ares	.02471	acres
"	100.	square meters
atmospheres	76.	cms. of mercury
"	29.92	inches of mercury
"	33.90	feet of water
"	10333.	kgs. per square meter
"	14.70	pounds per sq. inch
"	1.058	tons per sq. ft.
British thermal units	.2520	kilogram-calories
" " "	778.104	foot-pounds
" " "	.0003927	horse-power-hours
" " "	107.5	kilogram-meters
" " "	.0002928	kilowatt-hours
B. t. u. per min.	12.96	foot-pounds per sec.
" " "	.02356	horse-power
" " "	.01757	kilowatts
" " "	17.57	watts
bushels	1.244	cubic feet
"	2150.	cubic inches
"	.03524	cubic meters
"	4.	pecks
"	64.	pints (dry)
"	32.	quarts (dry)
centigrams	.01	grams
centiliters	.01	liters
centimeters	.3937	inches
"	.01	meters
"	393.7	mils
"	10.	millimeters
centimeters of mercury	.01316	atmospheres
" " "	.4461	feet of water
" " "	136.	kgs. per square meter
" " "	27.85	pounds per sq. foot
" " "	.1934	pounds per sq. inch
centimeters per second	1.969	feet per minute
" " "	.03281	feet per second
" " "	.036	kilometers per hour
" " "	.6	meters per minute
" " "	.02237	miles per hour
" " "	.0003728	miles per minute
circular mils	.000005067	square centimeters
" "	.0000007854	square inches
" "	.7854	square mils
cubic centimeters	.00003531	cubic feet
" "	.06102	cubic inches
" "	.000001	cubic meters
" "	.000001308	cubic yards
" "	.0002642	gallons
" "	.001	liters
" "	.002113	pints (liq.)
" "	.001057	quarts (liq.)
cubic feet	28320.	cubic cms.
" "	1728.	cubic inches
" "	.02832	cubic meters
" "	.03704	cubic yards

Conversion Factors

MULTIPLY	BY	TO OBTAIN
cubic feet (water)	7.481	U. S. gallons
" " "	28.32	liters
" " "	62.44	pounds (approx.)
" " "	59.84	pints (liq.)
" " "	29.92	quarts (liq.)
cubic feet per minute	472.	cubic cms. per sec.
" " " "	.1247	gallons per sec.
" " " "	.472	liters per second
" " " "	62.4	lbs. of water per min.
cubic ft. per sec. (water)	1.98	acre foot per day
" " " " "	60.	cubic feet per min.
" " " " "	3600.	cubic feet per hour
" " " " "	86400.	cubic feet per 24 hrs.
" " " " "	7.48	gallons per second
" " " " "	448.8	gallons per minute
" " " " "	26930.	gallons per hour
" " " " "	646317.	gallons per 24 hours
cubic inches	16.39	cubic centimeters
" "	.0005787	cubic feet
" "	.00001639	cubic meters
" "	.00002143	cubic yards
" "	.004329	gallons
" "	.01639	liters
" "	106100.	mil-feet
" "	.03463	pints (liq.)
" "	.01732	quarts (liq.)
cubic meters	1000000.	cubic centimeters
" "	35.31	cubic feet
" "	61023.	cubic inches
" "	1.308	cubic yards
" "	264.2	gallons
" "	1000.	liters
" "	2113.	pints (liq.)
" "	1057.	quarts (liq.)
cubic yards	27.	cubic feet
" "	46656.	cubic inches
" "	.7646	cubic meters
" "	202.	gallons
" "	764.6	liters
" "	1616.	pints (liq.)
" "	807.9	quarts (liq.)
cubic yards per minute	.45	cubic feet per second
" " " "	3.367	gallons per second
" " " "	12.74	liters per second
days	24.	hours
"	1440.	minutes
"	86400.	seconds
drams	1.772	grams
"	.0625	ounces
dynes	.001020	grams
"	.00007233	poundals
"	.000002248	pounds
fathoms	6.	feet
feet	30.48	centimeters
"	12.	inches
"	.3048	meters
"	1/3	yards
feet of water	.02950	atmospheres
" " "	.8826	inches of mercury
" " "	304.8	kgs. per square meter
" " "	62.43	lbs. per square foot

Conversion Factors

MULTIPLY	BY	TO OBTAIN
feet of water (cont'd)...	.4335	lbs. per square inch
feet per minute........	.5080	centimeters per sec.
" " "	.01667	feet per second
" " "	.01829	kilometers per hour
" " "	.3048	meters per minute
" " "	.01136	miles per hour
feet per second........	30.48	centimeters per sec.
" " "	1.097	kilometers per hour
" " "	.5921	knots per hour
" " "	18.29	meters per minute
" " "	.6818	miles per hour
" " "	.01136	miles per minute
feet per 100 feet.......	1.	per cent grade
feet per sec. per sec....	30.48	cms. per sec. per sec.
" " " " "	1.097	kms. per hour per sec.
" " " " "	.3048	meters per sec. per sec.
" " " " "	.6818	miles per hour per sec.
foot-pounds..........	.001286	British thermal units
" "	.0000005050	horse-power-hours
" "	1.356	joules
" "	.0003239	kilogram-calories
" "	.1383	kilogram-meters
" "	.0000003766	kilowatt-hours
foot-pounds per minute.	.001286	B. t. units per minute
" " " " .	.01667	foot-pounds per sec.
" " " " .	.00003030	horse-power
" " " " .	.0003241	kg.-calories per min.
" " " " .	.00002260	kilowatts
foot-pounds per second.	.07717	B. t. units per minute
" " " " .	.001818	horse-power
" " " " .	.01945	kg.-calories per min.
" " " " .	.001356	kilowatts
furlongs..............	40.	rods
gallons (water) U. S....	8.345	pounds
" "	.833111	Imperial gallons
" "	3785.	cubic centimeters
" "	.1337	cubic feet
" "	231.	cubic inches
" "	.003785	cubic meters
" "	.004951	cubic yards
" "	3.785	liters
" "	8.	pints (liq.)
" "	4.	quarts (liq.)
gallons per minute.....	.002228	cubic feet per second
" " "	.06308	liters per second
gallons per day........	.00000155	cubic feet per second
gills.................	.1183	liters
"	.25	pints (liq.)
grains (troy)..........	1.	grains (avoir.)
" "	.0648	grams
" "	.04167	pennyweights (troy)
grams................	980.6	dynes
"	15.43	grains (troy)
"	.001	kilograms
"	1000.	milligrams
"	.03527	ounces (avoir.)
"	.03215	ounces (troy)
"	.07093	poundals
"	.002205	pounds
gram-calories.........	.003968	British thermal units
gram-centimeters......	.00007233	foot-pounds

Conversion Factors

MULTIPLY	BY	TO OBTAIN
gram-centimeters (con't)	.00009807	joules
" "	.00001	kilogram-meters
hectares	2.471	acres
"	107600.	square feet
horse-power	42.41	B. t. units per min.
" "	33000.	foot-pounds per min.
" "	550.	foot-pounds per sec.
" "	1.014	horse-power (metric)
" "	10.69	kg.-calories per min.
" "	.7457	kilowatts
" "	745.7	watts
horse-power (boiler)	33520.	B. t. u. per hour
" " "	9.804	kilowatts
horse-power-hours	2545.	British thermal units
" " "	1980000.	foot-pounds
" " "	641.2	kilogram-calories
" " "	273700.	kilogram-meters
" " "	.7457	kilowatt-hours
inches	2.540	centimeters
"	1000.	mils
inches of mercury	.03342	atmospheres
" " "	1.133	feet of water
" " "	345.3	kgs. per square meter
" " "	70.73	pounds per sq. foot
" " "	.4912	pounds per sq. inch
inches of water	.002458	atmospheres
" " "	.07355	inches of mercury
" " "	25.40	kgs. per square meter
" " "	.5781	ounces per sq. inch
" " "	5.204	pounds per sq. ft.
" " "	.03613	pounds per sq. inch
joules	.7376	foot-pounds
"	.0002390	kilogram-calories
"	.1020	kilogram-meters
"	.0002778	watt-hours
kilograms	980665.	dynes
"	1000.	grams
"	70.93	poundals
"	2.205	pounds (avoir.)
"	.001102	tons (short)
kilogram-calories	3.968	British thermal units
" "	3088.	foot-pounds
" "	.001558	horse-power-hours
" "	4186.	joules
" "	426.9	kilogram-meters
" "	.001162	kilowatt-hours
kilogram calories per min	51.46	foot-pounds per sec.
" " " "	.09351	horse-power
" " " "	.06972	kilowatts
kilograms per cub. meter	.001	grams per cubic cm.
" " " "	.06243	pounds per cubic foot
" " " "	.00003613	pounds per cubic inch
kilometers	100000.	centimeters
"	3281.	feet
"	1000.	meters
"	.6214	miles
"	1094.	yards
kilometers per hour	27.78	centimeters per sec.
" " "	54.68	feet per minute
" " "	.9113	feet per second
" " "	.5396	knots per hour

Conversion Factors

MULTIPLY	BY	TO OBTAIN
kilometers per hr. (cont)	16.67	meters per minute
" " "	.6214	miles per hour
kilowatts	56.88	B. t. units per min.
"	44250.	foot-pounds per min.
"	737.6	foot-pounds per sec.
"	1.341	horse-power
"	14.34	kg.-calories per min.
"	1000.	watts
kilowatt-hours	3413.	British thermal units
" "	2655000.	foot-pounds
" "	1.341	horse-power-hours
" "	3600000.	joules
" "	860.5	kilogram-calories
" "	367100.	kilogram-meters
knots	6080.	feet
"	1.853	kilometers
"	1.152	miles
"	2027.	yards
knots per hour	51.48	centimeters per sec.
" " "	1.689	feet per second
" " "	1.853	kilometers per hour
" " "	1.152	miles per hour
links (engineer's)	12.	inches
links (surveyor's)	7.92	inches
liters	1000.	cubic centimeters
"	.03531	cubic feet
"	61.02	cubic inches
"	.001	cubic meters
"	.001308	cubic yards
"	.2642	gallons
"	2.113	pints (liq.)
"	1.057	quarts (liq.)
liters per min.	.0005885	cubic feet per second
" " "	.004403	gallons per second
lumens per sq. ft.	1.	foot-candles
meters	100.	centimeters
"	3.281	feet
"	39.37	inches
"	.001	kilometers
"	1000.	millimeters
"	1.094	yards
micrograms	.000001	grams
microliters	.000001	liters
miles	160900.	centimeters
"	5280.	feet
"	1.609	kilometers
"	1760.	yards
miles per hour	44.70	centimeters per sec.
" " "	88.	feet per minute
" " "	1.467	feet per second
" " "	1.609	kilometers per hour
" " "	.8684	knots per hour
" " "	26.82	meters per minute
miles per minute	2682.	centimeters per sec.
" " "	88.	feet per second
" " "	1.609	kilometers per min.
" " "	.8684	knots per minute
" " "	60.	miles per hour
mil-feet	.000009425	cubic inches
milligrams	.001	grams
milliliters	.001	liters

Conversion Factors

MULTIPLY	BY	TO OBTAIN
millimeters	.1	centimeters
"	.03937	inches
"	39.37	mils
mils	.002540	centimeters
"	.001	inches
months	30.42	days
"	730.	hours
"	43800.	minutes
"	2628000.	seconds
myriagrams	10.	kilograms
myriameters	10.	kilometers
myriawatts	10.	kilowatts
ounces (avoir.)	16.	drams
" "	437.5	grains
" "	28.35	grams
" "	.0625	pounds
ounces (fluid)	1.805	cubic inches
" "	.02957	liters
ounces (troy)	480.	grains (troy)
" "	31.10	grams
" "	20.	pennyweights (troy)
" "	.08333	pounds (troy)
ounces per square inch	.0625	pounds per sq. inch
pints (dry)	33.60	cubic inches
pints (liq.)	28.87	cubic inches
poundals	13826.	dynes
"	14.10	grams
"	.03108	pounds
pounds (avoir.)	444823.	dynes
" "	7000.	grains
" "	453.6	grams
" "	16.	ounces
" "	32.17	poundals
pounds (troy)	.8229	pounds (avoir.)
pound-feet	13560000.	centimeter-dynes
" "	13825.	centimeter-grams
" "	.1383	meter-kilograms
pounds of water	.01602	cubic feet
" " "	27.68	cubic inches
" " "	.1198	gallons
pounds of water per min.	.0002669	cubic feet per sec.
pounds per cubic foot	.01602	grams per cubic cm.
" " " "	16.02	kgs. per cubic meter
" " " "	.0005787	pounds per cubic inch
pounds per cubic inch	27.68	grams per cubic cm.
" " " "	27680.	kgs. per cubic meter
" " " "	1728.	pounds per cubic foot
" " " "	.000009425	pounds per mil foot
pounds per square foot	.01602	feet of water
" " " "	4.882	kgs. per square meter
" " " "	.006944	pounds per sq. inch
pounds per square inch	.06804	atmospheres
" " " "	2.307	feet of water
" " " "	2.036	inches of mercury
" " " "	703.1	kgs. per square meter
" " " "	144.	pounds per sq. foot
quarts (dry)	67.20	cubic inches
quarts (liq.)	57.75	cubic inches
radians	57.30	degrees
"	3438.	minutes
"	.637	quadrants

Conversion Factors

MULTIPLY	BY	TO OBTAIN
reams	500.	sheets
revolutions per minute	6.	degrees per second
" " "	.1047	radians per second
" " "	.01667	revolutions per sec.
rods	16.5	feet
square centimeters	197300.	circular mils
" "	.001076	square feet
" "	.1550	square inches
" "	.0001	square meters
" "	100.	square millimeters
square feet	.00002296	acres
" "	929.	square centimeters
" "	144.	square inches
" "	.09290	square meters
" "	.00000003587	square miles
" "	1/9	square yards
square inches	1273000.	circular mils
" "	6.452	square centimeters
" "	.006944	square feet
" "	1000000.	square mils
" "	645.2	square millimeters
square kilometers	247.1	acres
" "	10760000.	square feet
" "	1000000.	square meters
" "	.3861	square miles
" "	1196000.	square yards
square meters	.0002471	acres
" "	10.76	square feet
" "	.0000003861	square miles
" "	1.196	square yards
square miles	640.	acres
" "	27880000.	square feet
" "	2.590	square kilometers
" "	3098000.	square yards
square millimeters	1973.	circular mils
" "	.01	square centimeters
" "	.001550	square inches
square mils	1.273	circular mils
" "	.000006452	square centimeters
" "	.000001	square inches
square yards	.0002066	acres
" "	9.	square feet
" "	.8361	square meters
" "	.0000003228	square miles
tons (long)	1016.	kilograms
" "	2240.	pounds
tons (metric)	1000.	kilograms
" "	2205.	pounds (avoir.)
tons (short)	907.2	kilograms
" "	2000.	pounds
tons (short) per sq. ft.	9765.	kgs. per square meter
" " " " "	13.89	pounds per sq. inch
tons (short) per sq. in.	1406000.	kgs. per square meter
" " " " "	2000.	pounds per sq. inch
watts	.05688	B. t. units per min.
"	10000000.	ergs per second
"	44.26	foot-pounds per min.
"	.7376	foot-pounds per sec.
"	.001341	horse-power
"	.01434	kg.-calories per min.
"	.001	kilowatts

Conversion Factors

MULTIPLY	BY	TO OBTAIN
watt-hours	3.413	British thermal units
" "	2655.	foot-pounds
" "	.001341	horse-power-hours
" "	.86	kilogram-calories
" "	367.1	kilogram-meters
" "	.001	kilowatt-hours
yards	91.44	centimeters
"	3.	feet
"	36.	inches
"	.9144	meters

Table of Decimal Equivalents of Parts of 1 Inch

1/64	.015625	23/64	.359375	45/64	.703125
1/32	.03125	3/8	.375	23/32	.71875
3/64	.046875	25/64	.390625	47/64	.734375
1/16	.0625	13/32	.40625	3/4	.75
5/64	.078125	27/64	.421875	49/64	.765625
3/32	.09375	7/16	.4375	25/32	.78125
7/64	.109375	29/64	.453125	51/64	.796875
1/8	.125	15/32	.46875	13/16	.8125
9/64	.140625	31/64	.484375	53/64	.828125
5/32	.15625	1/2	.50	27/32	.84375
11/64	.171875	33/64	.515625	55/64	.859375
3/16	.1875	17/32	.53125	7/8	.875
13/64	.203125	35/64	.546875	57/64	.890625
7/32	.21875	9/16	.5625	29/32	.90625
15/64	.234375	37/64	.578125	59/64	.921875
1/4	.25	19/32	.59375	15/16	.9375
17/64	.265625	39/64	.609375	61/64	.953125
9/32	.28125	5/8	.625	31/32	.96875
19/64	.296875	41/64	.640625	63/64	.984375
5/16	.3125	21/32	.65625	1	1.00
21/64	.328125	43/64	.671875		
11/32	.34375	11/16	.6875		

Decimal of an Inch and of a Foot

Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	1/8		.2604	3 1/8		.5104	6 1/8		.7604	9 1/8
1/64	.015625	3/16	17/64	.265625	3 3/16	33/64	.515625	6 3/16	49/64	.765625	9 3/16
	.0208	1/4		.2708	3 1/4		.5208	6 1/4		.7708	9 1/4
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	3/8	9/32	.28125	3 3/8	17/32	.53125	6 3/8	25/32	.78125	9 3/8
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	1/2		.2917	3 1/2		.5417	6 1/2		.7917	9 1/2
3/64	.046875	9/16	19/64	.296875	3 9/16	35/64	.546875	6 9/16	51/64	.796875	9 9/16
	.0521	5/8		.3021	3 5/8		.5521	6 5/8		.8021	9 5/8
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	3/4	5/16	.3125	3 3/4	9/16	.5625	6 3/4	13/16	.8125	9 3/4
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	7/8		.3229	3 7/8		.5729	6 7/8		.8229	9 7/8
5/64	.078125	15/16	21/64	.328125	3 15/16	37/64	.578125	6 15/16	53/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1 1/8	11/32	.34375	4 1/8	19/32	.59375	7 1/8	27/32	.84375	10 1/8
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1 1/4		.3542	4 1/4		.6042	7 1/4		.8542	10 1/4
7/64	.109375	1 5/16	23/64	.359375	4 5/16	39/64	.609375	7 5/16	55/64	.859375	10 5/16
	.1146	1 3/8		.3646	4 3/8		.6146	7 3/8		.8646	10 3/8
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1 1/2	3/8	.3750	4 1/2	5/8	.6250	7 1/2	7/8	.8750	10 1/2
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1 5/8		.3854	4 5/8		.6354	7 5/8		.8854	10 5/8
9/64	.140625	1 11/16	25/64	.390625	4 11/16	41/64	.640625	7 11/16	57/64	.890625	10 11/16
	.1458	1 3/4		.3958	4 3/4		.6458	7 3/4		.8958	10 3/4
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1 7/8	13/32	.40625	4 7/8	21/32	.65625	7 7/8	29/32	.90625	10 7/8
	.1615	1 15/16		.4115	4 15/16		.6615	7 15/16		.9115	10 15/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	27/64	.421875	5 1/16	43/64	.671875	8 1/16	59/64	.921875	11 1/16
	.1771	2 1/8		.4271	5 1/8		.6771	8 1/8		.9271	11 1/8
	.1823	2 3/16		.4323	5 3/16		.6823	8 3/16		.9323	11 3/16
3/16	.1875	2 1/4	7/16	.4375	5 1/4	11/16	.6875	8 1/4	15/16	.9375	11 1/4
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2 3/8		.4479	5 3/8		.6979	8 3/8		.9479	11 3/8
13/64	.203125	2 7/16	29/64	.453125	5 7/16	45/64	.703125	8 7/16	61/64	.953125	11 7/16
	.2083	2 1/2		.4583	5 1/2		.7083	8 1/2		.9583	11 1/2
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2 5/8	15/32	.46875	5 5/8	23/32	.71875	8 5/8	31/32	.96875	11 5/8
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2 3/4		.4792	5 3/4		.7292	8 3/4		.9792	11 3/4
15/64	.234375	2 13/16	31/64	.484375	5 13/16	47/64	.734375	8 13/16	63/64	.984375	11 13/16
	.2396	2 7/8		.4896	5 7/8		.7396	8 7/8		.9896	11 7/8
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
1/64	.0002	.0491	5 1/8	20.6290	16.1007
1/32	.0008	.0982	5 1/4	21.6475	16.4934
1/16	.0031	.1964	5 3/8	22.6906	16.8861
1/8	.0123	.3927	5 1/2	23.7583	17.2788
3/16	.0276	.5890	5 5/8	24.8505	17.6715
1/4	.0491	.7854	5 3/4	25.9672	18.0642
5/16	.0767	.9817	5 7/8	27.1085	18.4569
3/8	.1105	1.1781	6	28.2743	18.8496
7/16	.1503	1.3745	6 1/8	29.4647	19.2423
1/2	.1964	1.5708	6 1/4	30.6796	19.6350
9/16	.2485	1.7672	6 3/8	31.9191	20.0277
5/8	.3068	1.9635	6 1/2	33.1831	20.4204
11/16	.3712	2.1598	6 5/8	34.4716	20.8131
3/4	.4418	2.3562	6 3/4	35.7847	21.2058
13/16	.5185	2.5525	6 7/8	37.1223	21.5984
7/8	.6013	2.7489	7	38.4845	21.9911
15/16	.6903	2.9452	7 1/8	39.8713	22.3838
1	.7854	3.1416	7 1/4	41.2825	22.7765
1 1/8	.9940	3.5343	7 3/8	42.7183	23.1692
1 1/4	1.2272	3.9270	7 1/2	44.1786	23.5619
1 3/8	1.4849	4.3197	7 5/8	45.6635	23.9546
1 1/2	1.7671	4.7124	7 3/4	47.1730	24.3473
1 5/8	2.0739	5.1051	7 7/8	48.7070	24.7400
1 3/4	2.4053	5.4978	8	50.2655	25.1327
1 7/8	2.7612	5.8905	8 1/8	51.8486	25.5254
2	3.1416	6.2832	8 1/4	53.4562	25.9181
2 1/8	3.5466	6.6759	8 3/8	55.0883	26.3108
2 1/4	3.9761	7.0686	8 1/2	56.7450	26.7035
2 3/8	4.4301	7.4613	8 5/8	58.4263	27.0962
2 1/2	4.9087	7.8540	8 3/4	60.1320	27.4889
2 5/8	5.4119	8.2467	8 7/8	61.8624	27.8816
2 3/4	5.9396	8.6394	9	63.6173	28.2743
2 7/8	6.4918	9.0321	9 1/8	65.3967	28.6670
3	7.0686	9.4248	9 1/4	67.2006	29.0597
3 1/8	7.6699	9.8175	9 3/8	69.0291	29.4524
3 1/4	8.2958	10.2102	9 1/2	70.8822	29.8451
3 3/8	8.9462	10.6029	9 5/8	72.7598	30.2378
3 1/2	9.6211	10.9956	9 3/4	74.6619	30.6305
3 5/8	10.3206	11.3883	9 7/8	76.589	31.0232
3 3/4	11.0447	11.7810	10	78.540	31.4159
3 7/8	11.7932	12.1737	10 1/8	80.516	31.8086
4	12.5664	12.5664	10 1/4	82.516	32.2013
4 1/8	13.3640	12.9591	10 3/8	84.541	32.5940
4 1/4	14.1863	13.3518	10 1/2	86.590	32.9867
4 3/8	15.0330	13.7445	10 5/8	88.664	33.3794
4 1/2	15.9043	14.1372	10 3/4	90.763	33.7721
4 5/8	16.8002	14.5299	10 7/8	92.886	34.1648
4 3/4	17.7205	14.9226	11	95.033	34.5575
4 7/8	18.6655	15.3153	11 1/8	97.205	34.9502
5	19.6350	15.7080	11 1/4	99.402	35.3429

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
11 ⅜	101.623	35.7356	17 ⅝	243.977	55.3706
11 ½	103.869	36.1283	17 ¾	247.450	55.7633
11 ⅝	106.139	36.5210	17 ⅞	250.947	56.1560
11 ¾	108.434	36.9137	18	254.469	56.5487
11 ⅞	110.753	37.3064	18 ⅛	258.016	56.9414
12	113.097	37.6991	18 ¼	261.587	57.3341
12 ⅛	115.466	38.0918	18 ⅜	265.182	57.7268
12 ¼	117.859	38.4845	18 ½	268.803	58.1195
12 ⅜	120.276	38.8772	18 ⅝	272.447	58.5122
12 ½	122.718	39.2699	18 ¾	276.117	58.9049
12 ⅝	125.185	39.6626	18 ⅞	279.810	59.2976
12 ¾	127.676	40.0553	19	283.529	59.6903
12 ⅞	130.192	40.4480	19 ⅛	287.272	60.0830
13	132.732	40.8407	19 ¼	291.039	60.4757
13 ⅛	135.297	41.2334	19 ⅜	294.831	60.8684
13 ¼	137.886	41.6261	19 ½	298.648	61.2611
13 ⅜	140.500	42.0188	19 ⅝	302.489	61.6538
13 ½	143.139	42.4115	19 ¾	306.354	62.0465
13 ⅝	145.802	42.8042	19 ⅞	310.245	62.4392
13 ¾	148.489	43.1969	20	314.159	62.8319
13 ⅞	151.201	43.5896	20 ⅛	318.099	63.2246
14	153.938	43.9823	20 ¼	322.062	63.6173
14 ⅛	156.699	44.3750	20 ⅜	326.051	64.0100
14 ¼	159.485	44.7677	20 ½	330.064	64.4026
14 ⅜	162.295	45.1604	20 ⅝	334.101	64.7953
14 ½	165.130	45.5531	20 ¾	338.163	65.1880
14 ⅝	167.989	45.9458	20 ⅞	342.250	65.5807
14 ¾	170.873	46.3385	21	346.361	65.9734
14 ⅞	173.782	46.7312	21 ⅛	350.496	66.3661
15	176.715	47.1239	21 ¼	354.656	66.7588
15 ⅛	179.672	47.5166	21 ⅜	358.841	67.1515
15 ¼	182.654	47.9093	21 ½	363.050	67.5442
15 ⅜	185.661	48.3020	21 ⅝	367.284	67.9369
15 ½	188.692	48.6947	21 ¾	371.542	68.3296
15 ⅝	191.748	49.0874	21 ⅞	375.825	68.7223
15 ¾	194.828	49.4801	22	380.133	69.1150
15 ⅞	197.933	49.8728	22 ⅛	384.465	69.5077
16	201.062	50.2655	22 ¼	388.821	69.9004
16 ⅛	204.216	50.6582	22 ⅜	393.202	70.2931
16 ¼	207.394	51.0509	22 ½	397.608	70.6858
16 ⅜	210.597	51.4436	22 ⅝	402.038	71.0785
16 ½	213.825	51.8363	22 ¾	406.493	71.4712
16 ⅝	217.077	52.2290	22 ⅞	410.972	71.8639
16 ¾	220.353	52.6217	23	415.476	72.2566
16 ⅞	223.654	53.0144	23 ⅛	420.004	72.6493
17	226.980	53.4071	23 ¼	424.557	73.0420
17 ⅛	230.330	53.7998	23 ⅜	429.134	73.4347
17 ¼	233.705	54.1925	23 ½	433.736	73.8274
17 ⅜	237.104	54.5852	23 ⅝	438.363	74.2201
17 ½	240.528	54.9779	23 ¾	443.014	74.6128

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
23 ⅞	447.689	75.0055	30 ⅛	712.761	94.6405
24	452.389	75.3982	30 ¼	718.688	95.0332
24 ⅛	457.114	75.7909	30 ⅜	724.640	95.4259
24 ¼	461.863	76.1836	30 ½	730.617	95.8186
24 ⅜	466.637	76.5763	30 ⅝	736.618	96.2113
24 ½	471.435	76.9690	30 ¾	742.643	96.6040
24 ⅝	476.258	77.3617	30 ⅞	748.693	96.9967
24 ¾	481.105	77.7544	31	754.768	97.3894
24 ⅞	485.977	78.1471	31 ⅛	760.867	97.7821
25	490.874	78.5398	31 ¼	766.990	98.1748
25 ⅛	495.795	78.9325	31 ⅜	773.139	98.5675
25 ¼	500.740	79.3252	31 ½	779.311	98.9602
25 ⅜	505.711	79.7179	31 ⅝	785.509	99.3529
25 ½	510.705	80.1106	31 ¾	791.730	99.7456
25 ⅝	515.724	80.5033	31 ⅞	797.977	100.1383
25 ¾	520.768	80.8960	32	804.248	100.5310
25 ⅞	525.836	81.2887	32 ⅛	810.543	100.9237
26	530.929	81.6814	32 ¼	816.863	101.3164
26 ⅛	536.047	82.0741	32 ⅜	823.208	101.7091
26 ¼	541.188	82.4668	32 ½	829.577	102.1018
26 ⅜	546.355	82.8595	32 ⅝	835.970	102.4945
26 ½	551.546	83.2522	32 ¾	842.389	102.8872
26 ⅝	556.761	83.6449	32 ⅞	848.831	103.280
26 ¾	562.001	84.0376	33	855.299	103.673
26 ⅞	567.266	84.4303	33 ⅛	861.790	104.065
27	572.555	84.8230	33 ¼	868.307	104.458
27 ⅛	577.869	85.2157	33 ⅜	874.848	104.851
27 ¼	583.207	85.6084	33 ½	881.413	105.243
27 ⅜	588.570	86.0011	33 ⅝	888.003	105.636
27 ½	593.957	86.3938	33 ¾	894.618	106.029
27 ⅝	599.369	86.7865	33 ⅞	901.257	106.421
27 ¾	604.806	87.1792	34	907.920	106.814
27 ⅞	610.267	87.5719	34 ⅛	914.608	107.207
28	615.752	87.9646	34 ¼	921.321	107.600
28 ⅛	621.262	88.3573	34 ⅜	928.058	107.992
28 ¼	626.797	88.7500	34 ½	934.820	108.385
28 ⅜	632.356	89.1427	34 ⅝	941.607	108.778
28 ½	637.940	89.5354	34 ¾	948.417	109.170
28 ⅝	643.548	89.9281	34 ⅞	955.253	109.563
28 ¾	649.181	90.3208	35	962.113	109.956
28 ⅞	654.838	90.7135	35 ⅛	968.997	110.348
29	660.520	91.1062	35 ¼	975.906	110.741
29 ⅛	666.226	91.4989	35 ⅜	982.840	111.134
29 ¼	671.957	91.8916	35 ½	989.798	111.527
29 ⅜	677.713	92.2843	35 ⅝	996.781	111.919
29 ½	683.493	92.6770	35 ¾	1003.788	112.312
29 ⅝	689.297	93.0697	35 ⅞	1010.820	112.705
29 ¾	695.126	93.4624	36	1017.876	113.097
29 ⅞	700.980	93.8551	36 ⅛	1024.957	113.490
30	706.858	94.2478	36 ¼	1032.062	113.883

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
36 3/8	1039.192	114.275	42 5/8	1426.983	133.910
36 1/2	1046.347	114.668	42 3/4	1435.364	134.303
36 5/8	1053.526	115.061	42 7/8	1443.770	134.696
36 3/4	1060.729	115.454	43	1452.201	135.088
36 7/8	1067.957	115.846	43 1/8	1460.657	135.481
37	1075.210	116.239	43 1/4	1469.136	135.874
37 1/8	1082.487	116.632	43 3/8	1477.641	136.267
37 1/4	1089.789	117.024	43 1/2	1486.170	136.659
37 3/8	1097.115	117.417	43 5/8	1494.723	137.052
37 1/2	1104.466	117.810	43 3/4	1503.301	137.445
37 5/8	1111.842	118.202	43 7/8	1511.904	137.837
37 3/4	1119.241	118.595	44	1520.531	138.230
37 7/8	1126.666	118.988	44 1/8	1529.183	138.623
38	1134.115	119.381	44 1/4	1537.859	139.015
38 1/8	1141.589	119.773	44 3/8	1546.56	139.408
38 1/4	1149.087	120.166	44 1/2	1555.28	139.801
38 3/8	1156.609	120.559	44 5/8	1564.03	140.194
38 1/2	1164.156	120.951	44 3/4	1572.81	140.586
38 5/8	1171.728	121.344	44 7/8	1581.61	140.979
38 3/4	1179.324	121.737	45	1590.43	141.372
38 7/8	1186.945	122.129	45 1/8	1599.28	141.764
39	1194.591	122.522	45 1/4	1608.15	142.157
39 1/8	1202.261	122.915	45 3/8	1617.05	142.550
39 1/4	1209.955	123.308	45 1/2	1625.97	142.942
39 3/8	1217.674	123.700	45 5/8	1634.92	143.335
39 1/2	1225.417	124.093	45 3/4	1643.89	143.728
39 5/8	1233.186	124.486	45 7/8	1652.88	144.121
39 3/4	1240.978	124.878	46	1661.90	144.513
39 7/8	1248.795	125.271	46 1/8	1670.95	144.906
40	1256.637	125.664	46 1/4	1680.02	145.299
40 1/8	1264.503	126.056	46 3/8	1689.11	145.691
40 1/4	1272.394	126.449	46 1/2	1698.23	146.084
40 3/8	1280.309	126.842	46 5/8	1707.37	146.477
40 1/2	1288.249	127.235	46 3/4	1716.54	146.869
40 5/8	1296.214	127.627	46 7/8	1725.73	147.262
40 3/4	1304.203	128.020	47	1734.94	147.655
40 7/8	1312.216	128.413	47 1/8	1744.19	148.048
41	1320.254	128.805	47 1/4	1753.45	148.440
41 1/8	1328.317	129.198	47 3/8	1762.74	148.833
41 1/4	1336.404	129.591	47 1/2	1772.05	149.226
41 3/8	1344.516	129.983	47 5/8	1781.39	149.618
41 1/2	1352.652	130.376	47 3/4	1790.76	150.011
41 5/8	1360.813	130.769	47 7/8	1800.14	150.404
41 3/4	1368.998	131.161	48	1809.56	150.796
41 7/8	1377.208	131.554	48 1/8	1818.99	151.189
42	1385.442	131.947	48 1/4	1828.46	151.582
42 1/8	1393.701	132.340	48 3/8	1837.94	151.975
42 1/4	1401.985	132.732	48 1/2	1847.45	152.367
42 3/8	1410.293	133.125	48 5/8	1856.99	152.760
42 1/2	1418.625	133.518	48 3/4	1866.55	153.153

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
48 ⅞	1876.13	153.545	55 ⅛	2386.64	173.180
49	1885.74	153.938	55 ¼	2397.48	173.573
49 ⅛	1895.37	154.331	55 ⅜	2408.34	173.966
49 ¼	1905.03	154.723	55 ½	2419.22	174.358
49 ⅜	1914.71	155.116	55 ⅝	2430.13	174.751
49 ½	1924.42	155.509	55 ¾	2441.07	175.144
49 ⅝	1934.15	155.902	55 ⅞	2452.03	175.536
49 ¾	1943.91	156.294	56	2463.01	175.929
49 ⅞	1953.69	156.687	56 ⅛	2474.02	176.322
50	1963.50	157.080	56 ¼	2485.05	176.715
50 ⅛	1973.33	157.472	56 ⅜	2496.11	177.107
50 ¼	1983.18	157.865	56 ½	2507.19	177.500
50 ⅜	1993.06	158.258	56 ⅝	2518.29	177.893
50 ½	2002.96	158.650	56 ¾	2529.42	178.285
50 ⅝	2012.89	159.043	56 ⅞	2540.58	178.678
50 ¾	2022.84	159.436	57	2551.76	179.071
50 ⅞	2032.82	159.829	57 ⅛	2562.96	179.463
51	2042.82	160.221	57 ¼	2574.19	179.856
51 ⅛	2052.85	160.614	57 ⅜	2585.44	180.249
51 ¼	2062.90	161.007	57 ½	2596.72	180.642
51 ⅜	2072.97	161.399	57 ⅝	2608.03	181.034
51 ½	2083.07	161.792	57 ¾	2619.35	181.427
51 ⅝	2093.20	162.185	57 ⅞	2630.70	181.820
51 ¾	2103.35	162.577	58	2642.08	182.212
51 ⅞	2113.52	162.970	58 ⅛	2653.48	182.605
52	2123.72	163.363	58 ¼	2664.91	182.998
52 ⅛	2133.94	163.756	58 ⅜	2676.35	183.390
52 ¼	2144.19	164.148	58 ½	2687.83	183.783
52 ⅜	2154.46	164.541	58 ⅝	2699.33	184.176
52 ½	2164.75	164.934	58 ¾	2710.85	184.569
52 ⅝	2175.07	165.326	58 ⅞	2722.40	184.961
52 ¾	2185.42	165.719	59	2733.97	185.354
52 ⅞	2195.79	166.112	59 ⅛	2745.57	185.747
53	2206.18	166.504	59 ¼	2757.19	186.139
53 ⅛	2216.60	166.897	59 ⅜	2768.84	186.532
53 ¼	2227.05	167.290	59 ½	2780.51	186.925
53 ⅜	2237.51	167.683	59 ⅝	2792.20	187.317
53 ½	2248.01	168.075	59 ¾	2803.92	187.710
53 ⅝	2258.52	168.468	59 ⅞	2815.66	188.103
53 ¾	2269.06	168.861	60	2827.43	188.496
53 ⅞	2279.63	169.253	60 ⅛	2839.23	188.888
54	2290.22	169.646	60 ¼	2851.04	189.281
54 ⅛	2300.84	170.039	60 ⅜	2862.89	189.674
54 ¼	2311.48	170.431	60 ½	2874.75	190.066
54 ⅜	2322.14	170.824	60 ⅝	2886.65	190.459
54 ½	2332.83	171.217	60 ¾	2898.56	190.852
54 ⅝	2343.54	171.609	60 ⅞	2910.50	191.244
54 ¾	2354.28	172.002	61	2922.47	191.637
54 ⅞	2365.04	172.395	61 ⅛	2934.46	192.030
55	2375.83	172.788	61 ¼	2946.47	192.423

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
61 ⅜	2958.51	192.815	67 ⅝	3591.74	212.450
61 ½	2970.57	193.208	67 ¾	3605.03	212.843
61 ⅝	2982.66	193.601	67 ⅞	3618.34	213.236
61 ¾	2994.77	193.993	68	3631.68	213.628
61 ⅞	3006.91	194.386	68 ⅛	3645.05	214.021
62	3019.07	194.779	68 ¼	3658.43	214.414
62 ⅛	3031.26	195.171	68 ⅜	3671.85	214.806
62 ¼	3043.47	195.564	68 ½	3685.28	215.199
62 ⅜	3055.70	195.957	68 ⅝	3698.75	215.592
62 ½	3067.96	196.350	68 ¾	3712.23	215.984
62 ⅝	3080.25	196.742	68 ⅞	3725.74	216.377
62 ¾	3092.55	197.135	69	3739.28	216.770
62 ⅞	3104.89	197.528	69 ⅛	3752.84	217.163
63	3117.25	197.920	69 ¼	3766.43	217.555
63 ⅛	3129.63	198.313	69 ⅜	3780.04	217.948
63 ¼	3142.03	198.706	69 ½	3793.67	218.341
63 ⅜	3154.47	199.098	69 ⅝	3807.33	218.733
63 ½	3166.92	199.491	69 ¾	3821.01	219.126
63 ⅝	3179.40	199.884	69 ⅞	3834.72	219.519
63 ¾	3191.91	200.277	70	3848.45	219.911
63 ⅞	3204.44	200.669	70 ⅛	3862.21	220.304
64	3216.99	201.062	70 ¼	3875.99	220.697
64 ⅛	3229.57	201.455	70 ⅜	3889.79	221.090
64 ¼	3242.17	201.847	70 ½	3903.63	221.482
64 ⅜	3254.80	202.240	70 ⅝	3917.48	221.875
64 ½	3267.45	202.633	70 ¾	3931.36	222.268
64 ⅝	3280.13	203.025	70 ⅞	3945.26	222.660
64 ¾	3292.83	203.418	71	3959.19	223.053
64 ⅞	3305.56	203.811	71 ⅛	3973.15	223.446
65	3318.31	204.204	71 ¼	3987.12	223.838
65 ⅛	3331.08	204.596	71 ⅜	4001.13	224.231
65 ¼	3343.88	204.989	71 ½	4015.15	224.624
65 ⅜	3356.71	205.382	71 ⅝	4029.20	225.017
65 ½	3369.55	205.774	71 ¾	4043.28	225.409
65 ⅝	3382.43	206.167	71 ⅞	4057.38	225.802
65 ¾	3395.33	206.560	72	4071.50	226.195
65 ⅞	3408.25	206.952	72 ⅛	4085.65	226.587
66	3421.19	207.345	72 ¼	4099.83	226.980
66 ⅛	3434.17	207.738	72 ⅜	4114.03	227.373
66 ¼	3447.16	208.131	72 ½	4128.25	227.765
66 ⅜	3460.18	208.523	72 ⅝	4142.50	228.158
66 ½	3473.23	208.916	72 ¾	4156.77	228.551
66 ⅝	3486.30	209.309	72 ⅞	4171.07	228.944
66 ¾	3499.39	209.701	73	4185.39	229.336
66 ⅞	3512.51	210.094	73 ⅛	4199.73	229.729
67	3525.65	210.487	73 ¼	4214.10	230.122
67 ⅛	3538.82	210.879	73 ⅜	4228.50	230.514
67 ¼	3552.01	211.272	73 ½	4242.92	230.907
67 ⅜	3565.23	211.665	73 ⅝	4257.36	231.300
67 ½	3578.47	212.058	73 ¾	4271.83	231.692

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
73 ⅞	4286.32	232.085	80 ⅛	5042.27	251.720
74	4300.84	232.478	80 ¼	5058.01	252.113
74 ⅛	4315.38	232.871	80 ⅜	5073.78	252.506
74 ¼	4329.95	233.263	80 ½	5089.58	252.898
74 ⅜	4344.54	233.656	80 ⅝	5105.39	253.291
74 ½	4359.16	234.049	80 ¾	5121.24	253.684
74 ⅝	4373.80	234.441	80 ⅞	5137.11	254.076
74 ¾	4388.46	234.834	81	5153.00	254.469
74 ⅞	4403.15	235.227	81 ⅛	5168.91	254.862
75	4417.86	235.619	81 ¼	5184.86	255.254
75 ⅛	4432.60	236.012	81 ⅜	5200.82	255.647
75 ¼	4447.37	236.405	81 ½	5216.81	256.040
75 ⅜	4462.15	236.798	81 ⅝	5232.83	256.433
75 ½	4476.97	237.190	81 ¾	5248.87	256.825
75 ⅝	4491.80	237.583	81 ⅞	5264.93	257.218
75 ¾	4506.66	237.976	82	5281.02	257.611
75 ⅞	4521.55	238.368	82 ⅛	5297.13	258.003
76	4536.46	238.761	82 ¼	5313.27	258.396
76 ⅛	4551.39	239.154	82 ⅜	5329.43	258.789
76 ¼	4566.35	239.546	82 ½	5345.62	259.181
76 ⅜	4581.34	239.939	82 ⅝	5361.83	259.574
76 ½	4596.35	240.332	82 ¾	5378.06	259.967
76 ⅝	4611.38	240 725	82 ⅞	5394.32	260.359
76 ¾	4626.44	241.117	83	5410.61	260.752
76 ⅞	4641.52	241.510	83 ⅛	5426.92	261.145
77	4656.63	241.903	83 ¼	5443.25	261.538
77 ⅛	4671.76	242.295	83 ⅜	5459.61	261.930
77 ¼	4686.91	242.688	83 ½	5475.99	262.323
77 ⅜	4702.09	243.081	83 ⅝	5492.40	262.716
77 ½	4717.30	243.473	83 ¾	5508.83	263.108
77 ⅝	4732.53	243.866	83 ⅞	5525.29	263.501
77 ¾	4747.78	244.259	84	5541.77	263.894
77 ⅞	4763.06	244.652	84 ⅛	5558.28	264.286
78	4778.36	245.044	84 ¼	5574.81	264.679
78 ⅛	4793.69	245.437	84 ⅜	5591.36	265.072
78 ¼	4809.04	245.830	84 ½	5607.94	265.465
78 ⅜	4824.42	246.222	84 ⅝	5624.54	265.857
78 ½	4839.82	246.615	84 ¾	5641.17	266.250
78 ⅝	4855.25	247.008	84 ⅞	5657.82	266.643
78 ¾	4870.70	247.400	85	5674.50	267.035
78 ⅞	4886.17	247.793	85 ⅛	5691.20	267.428
79	4901.67	248.186	85 ¼	5707.93	267.821
79 ⅛	4917.19	248.579	85 ⅜	5724.68	268.213
79 ¼	4932.74	248.971	85 ½	5741.46	268.606
79 ⅜	4948.32	249.364	85 ⅝	5758.26	268.999
79 ½	4963.91	249.757	85 ¾	5775.08	269.392
79 ⅝	4979.53	250.149	85 ⅞	5791.93	269.784
79 ¾	4995.18	250.542	86	5808.80	270.177
79 ⅞	5010.85	250.935	86 ⅛	5825.70	270.570
80	5026.55	251.327	86 ¼	5842.63	270.962

Areas and Circumferences of Circles

Diam.	Area	Circum.	Diam.	Area	Circum.
86 3/8	5859.57	271.355	93 1/4	6829.48	292.954
86 1/2	5876.55	271.748	93 3/8	6847.80	293.346
86 5/8	5893.54	272.140	93 1/2	6866.15	293.739
86 3/4	5910.56	272.533	93 5/8	6884.52	294.132
86 7/8	5927.61	272.926	93 3/4	6902.91	294.524
87	5944.68	273.319	93 7/8	6921.33	294.917
87 1/8	5961.77	273.711	94	6939.78	295.310
87 1/4	5978.89	274.104	94 1/8	6958.25	295.702
87 3/8	5996.04	274.497	94 1/4	6976.74	296.095
87 1/2	6013.20	274.889	94 3/8	6995.26	296.488
87 5/8	6030.40	275.282	94 1/2	7013.80	296.881
87 3/4	6047.62	275.675	94 5/8	7032.37	297.273
87 7/8	6064.86	276.067	94 3/4	7050.96	297.666
88	6082.12	276.460	94 7/8	7069.58	298.059
88 1/8	6099.41	276.853	95	7088.22	298.451
88 1/4	6116.73	277.246	95 1/8	7106.88	298.844
88 3/8	6134.07	277.638	95 1/4	7125.57	299.237
88 1/2	6151.43	278.031	95 3/8	7144.29	299.629
88 5/8	6168.82	278.424	95 1/2	7163.03	300.022
88 3/4	6186.24	278.816	95 5/8	7181.79	300.415
88 7/8	6203.68	279.209	95 3/4	7200.58	300.807
89	6221.14	279.602	95 7/8	7219.39	301.200
89 1/8	6238.63	279.994	96	7238.23	301.593
89 1/4	6256.14	280.387	96 1/8	7257.09	301.986
89 3/8	6273.67	280.780	96 1/4	7275.98	302.378
89 1/2	6291.24	281.173	96 3/8	7294.89	302.771
89 5/8	6308.82	281.565	96 1/2	7313.82	303.164
89 3/4	6326.43	281.958	96 5/8	7332.78	303.556
89 7/8	6344.07	282.351	96 3/4	7351.77	303.949
90	6361.73	282.743	96 7/8	7370.78	304.342
90 1/8	6379.41	283.136	97	7389.81	304.734
90 1/4	6397.12	283.529	97 1/8	7408.87	305.127
90 3/8	6414.85	283.921	97 1/4	7427.95	305.520
90 1/2	6432.61	284.314	97 3/8	7447.06	305.913
90 5/8	6450.39	284.707	97 1/2	7466.19	306.305
90 3/4	6468.20	285.100	97 5/8	7485.35	306.698
90 7/8	6486.03	285.492	97 3/4	7504.53	307.091
91	6503.88	285.885	97 7/8	7523.73	307.483
91 1/8	6521.76	286.278	98	7542.96	307.876
91 1/4	6539.67	286.670	98 1/8	7562.22	308.269
91 3/8	6557.60	287.063	98 1/4	7581.50	308.661
91 1/2	6575.55	287.456	98 3/8	7600.80	309.054
91 5/8	6593.53	287.848	98 1/2	7620.13	309.447
91 3/4	6611.53	288.241	98 5/8	7639.48	309.840
91 7/8	6629.56	288.634	98 3/4	7658.86	310.232
92	6647.61	289.027	98 7/8	7678.26	310.625
92 1/8	6665.69	289.419	99	7697.69	311.018
92 1/4	6683.79	289.812	99 1/8	7717.14	311.410
92 3/8	6701.91	290.205	99 1/4	7736.61	311.803
92 1/2	6720.06	290.597	99 3/8	7756.11	312.196
92 5/8	6738.24	290.990	99 1/2	7775.64	312.588
92 3/4	6756.44	291.383	99 5/8	7795.19	312.981
92 7/8	6774.66	291.775	99 3/4	7814.76	313.374
93	6792.91	292.168	99 7/8	7834.36	313.767
93 1/8	6811.18	292.561	100	7853.98	314.159

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
1	3.142	0.7854	1	1	1.0000	1.0000	0.00000
2	6.283	3.1416	4	8	1.4142	1.2599	0.30103
3	9.425	7.0686	9	27	1.7321	1.4422	0.47712
4	12.566	12.5664	16	64	2.0000	1.5874	0.60206
5	15.708	19.6350	25	125	2.2361	1.7100	0.69897
6	18.850	28.2743	36	216	2.4495	1.8171	0.77815
7	21.991	38.4845	49	343	2.6458	1.9129	0.84510
8	25.133	50.2655	64	512	2.8284	2.0000	0.90309
9	28.274	63.6173	81	729	3.0000	2.0801	0.95424
10	31.416	78.5398	100	1000	3.1623	2.1544	1.00000
11	34.558	95.0332	121	1331	3.3166	2.2240	1.04139
12	37.699	113.097	144	1728	3.4641	2.2894	1.07918
13	40.841	132.732	169	2197	3.6056	2.3513	1.11394
14	43.982	153.938	196	2744	3.7417	2.4101	1.14613
15	47.124	176.715	225	3375	3.8730	2.4662	1.17609
16	50.265	201.062	256	4096	4.0000	2.5198	1.20412
17	53.407	226.980	289	4913	4.1231	2.5713	1.23045
18	56.549	254.469	324	5832	4.2426	2.6207	1.25527
19	59.690	283.529	361	6859	4.3589	2.6684	1.27875
20	62.832	314.159	400	8000	4.4721	2.7144	1.30103
21	65.973	346.361	441	9261	4.5826	2.7589	1.32222
22	69.115	380.133	484	10648	4.6904	2.8020	1.34242
23	72.257	415.476	529	12167	4.7958	2.8439	1.36173
24	75.398	452.389	576	13824	4.8990	2.8845	1.38021
25	78.540	490.874	625	15625	5.0000	2.9240	1.39794
26	81.681	530.929	676	17576	5.0990	2.9625	1.41497
27	84.823	572.555	729	19683	5.1962	3.0000	1.43136
28	87.965	615.752	784	21952	5.2915	3.0366	1.44716
29	91.106	660.520	841	24389	5.3852	3.0723	1.46240
30	94.248	706.858	900	27000	5.4772	3.1072	1.47712
31	97.389	754.768	961	29791	5.5678	3.1414	1.49136
32	100.53	804.248	1024	32768	5.6569	3.1748	1.50515
33	103.67	855.299	1089	35937	5.7446	3.2075	1.51851
34	106.81	907.920	1156	39304	5.8310	3.2396	1.53148
35	109.96	962.113	1225	42875	5.9161	3.2711	1.54407
36	113.10	1017.88	1296	46656	6.0000	3.3019	1.55630
37	116.24	1075.21	1369	50653	6.0828	3.3322	1.56820
38	119.38	1134.11	1444	54872	6.1644	3.3620	1.57978
39	122.52	1194.59	1521	59319	6.2450	3.3912	1.59106
40	125.66	1256.64	1600	64000	6.3246	3.4200	1.60206
41	128.81	1320.25	1681	68921	6.4031	3.4482	1.61278
42	131.95	1385.44	1764	74088	6.4807	3.4760	1.62325
43	135.09	1452.20	1849	79507	6.5574	3.5034	1.63347
44	138.23	1520.53	1936	85184	6.6332	3.5303	1.64345
45	141.37	1590.43	2025	91125	6.7082	3.5569	1.65321
46	144.51	1661.90	2116	97336	6.7823	3.5830	1.66276
47	147.65	1734.94	2209	103823	6.8557	3.6088	1.67210
48	150.80	1809.56	2304	110592	6.9282	3.6342	1.68124
49	153.94	1885.74	2401	117649	7.0000	3.6593	1.69020

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
50	157.08	1963.50	2500	125000	7.0711	3.6840	1.69897
51	160.22	2042.82	2601	132651	7.1414	3.7084	1.70757
52	163.36	2123.72	2704	140608	7.2111	3.7325	1.71600
53	166.50	2206.18	2809	148877	7.2801	3.7563	1.72428
54	169.65	2290.22	2916	157464	7.3485	3.7798	1.73239
55	172.79	2375.83	3025	166375	7.4162	3.8030	1.74036
56	175.93	2463.01	3136	175616	7.4833	3.8259	1.74819
57	179.07	2551.76	3249	185193	7.5498	3.8485	1.75587
58	182.21	2642.08	3364	195112	7.6158	3.8709	1.76343
59	185.35	2733.97	3481	205379	7.6811	3.8930	1.77085
60	188.50	2827.43	3600	216000	7.7460	3.9149	1.77815
61	191.64	2922.47	3721	226981	7.8102	3.9365	1.78533
62	194.78	3019.07	3844	238328	7.8740	3.9579	1.79239
63	197.92	3117.25	3969	250047	7.9373	3.9791	1.79934
64	201.06	3216.99	4096	262144	8.0000	4.0000	1.80618
65	204.20	3318.31	4225	274625	8.0623	4.0207	1.81291
66	207.35	3421.19	4356	287496	8.1240	4.0412	1.81954
67	210.49	3525.65	4489	300763	8.1854	4.0615	1.82607
68	213.63	3631.68	4624	314432	8.2462	4.0817	1.83251
69	216.77	3739.28	4761	328509	8.3066	4.1016	1.83885
70	219.91	3848.45	4900	343000	8.3666	4.1213	1.84510
71	223.05	3959.19	5041	357911	8.4261	4.1408	1.85126
72	226.19	4071.50	5184	373248	8.4853	4.1602	1.85733
73	229.34	4185.39	5329	389017	8.5440	4.1793	1.86332
74	232.48	4300.84	5476	405224	8.6023	4.1983	1.86923
75	235.62	4417.86	5625	421875	8.6603	4.2172	1.87506
76	238.76	4536.46	5776	438976	8.7178	4.2358	1.88081
77	241.90	4656.63	5929	456533	8.7750	4.2543	1.88649
78	245.04	4778.36	6084	474552	8.8318	4.2727	1.89209
79	248.19	4901.67	6241	493039	8.8882	4.2908	1.89763
80	251.33	5026.55	6400	512000	8.9443	4.3089	1.90309
81	254.47	5153.00	6561	531441	9.0000	4.3267	1.90849
82	257.61	5281.02	6724	551368	9.0554	4.3445	1.91381
83	260.75	5410.61	6889	571787	9.1104	4.3621	1.91908
84	263.89	5541.77	7056	592704	9.1652	4.3795	1.92428
85	267.04	5674.50	7225	614125	9.2195	4.3968	1.92942
86	270.18	5808.80	7396	636056	9.2736	4.4140	1.93450
87	273.32	5944.68	7569	658503	9.3274	4.4310	1.93952
88	276.46	6082.12	7744	681472	9.3808	4.4480	1.94448
89	279.60	6221.14	7921	704969	9.4340	4.4647	1.94939
90	282.74	6361.73	8100	729000	9.4868	4.4814	1.95424
91	285.88	6503.88	8281	753571	9.5394	4.4979	1.95904
92	289.03	6647.61	8464	778688	9.5917	4.5144	1.96379
93	292.17	6792.91	8649	804357	9.6437	4.5307	1.96848
94	295.31	6939.78	8836	830584	9.6954	4.5468	1.97313
95	298.45	7088.22	9025	857375	9.7468	4.5629	1.97772
96	301.59	7238.23	9216	884736	9.7980	4.5789	1.98227
97	304.73	7389.81	9409	912673	9.8489	4.5947	1.98677
98	307.88	7542.96	9604	941192	9.8995	4.6104	1.99123
99	311.02	7697.69	9801	970299	9.9499	4.6261	1.99564

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
100	314.16	7853.98	10000	1000000	10.0000	4.6416	2.00000
101	317.30	8011.85	10201	1030301	10.0499	4.6570	2.00432
102	320.44	8171.28	10404	1061208	10.0995	4.6723	2.00860
103	323.58	8332.29	10609	1092727	10.1489	4.6875	2.01284
104	326.73	8494.87	10816	1124864	10.1980	4.7027	2.01703
105	329.87	8659.01	11025	1157625	10.2470	4.7177	2.02119
106	333.01	8824.73	11236	1191016	10.2956	4.7326	2.02531
107	336.15	8992.02	11449	1225043	10.3441	4.7475	2.02938
108	339.29	9160.88	11664	1259712	10.3923	4.7622	2.03342
109	342.43	9331.32	11881	1295029	10.4403	4.7769	2.03743
110	345.58	9503.32	12100	1331000	10.4881	4.7914	2.04139
111	348.72	9676.89	12321	1367631	10.5357	4.8059	2.04532
112	351.86	9852.03	12544	1404928	10.5830	4.8203	2.04922
113	355.00	10028.7	12769	1442897	10.6301	4.8346	2.05308
114	358.14	10207.0	12996	1481544	10.6771	4.8488	2.05690
115	361.28	10386.9	13225	1520875	10.7238	4.8629	2.06070
116	364.42	10568.3	13456	1560896	10.7703	4.8770	2.06446
117	367.57	10751.3	13689	1601613	10.8167	4.8910	2.06819
118	370.71	10935.9	13924	1643032	10.8628	4.9049	2.07188
119	373.85	11122.0	14161	1685159	10.9087	4.9187	2.07555
120	376.99	11309.7	14400	1728000	10.9545	4.9324	2.07918
121	380.13	11499.0	14641	1771561	11.0000	4.9461	2.08279
122	383.27	11689.9	14884	1815848	11.0454	4.9597	2.08636
123	386.42	11882.3	15129	1860867	11.0905	4.9732	2.08991
124	389.56	12076.3	15376	1906624	11.1355	4.9866	2.09342
125	392.70	12271.8	15625	1953125	11.1803	5.0000	2.09691
126	395.84	12469.0	15876	2000376	11.2250	5.0133	2.10037
127	398.98	12667.7	16129	2048383	11.2694	5.0265	2.10380
128	402.12	12868.0	16384	2097152	11.3137	5.0397	2.10721
129	405.27	13069.8	16641	2146689	11.3578	5.0528	2.11059
130	408.41	13273.2	16900	2197000	11.4018	5.0658	2.11394
131	411.55	13478.2	17161	2248091	11.4455	5.0788	2.11727
132	414.69	13684.8	17424	2299968	11.4891	5.0916	2.12057
133	417.83	13892.9	17689	2352637	11.5326	5.1045	2.12385
134	420.97	14102.6	17956	2406104	11.5758	5.1172	2.12710
135	424.12	14313.9	18225	2460375	11.6190	5.1299	2.13033
136	427.26	14526.7	18496	2515456	11.6619	5.1426	2.13354
137	430.40	14741.1	18769	2571353	11.7047	5.1551	2.13672
138	433.54	14957.1	19044	2628072	11.7473	5.1676	2.13988
139	436.68	15174.7	19321	2685619	11.7898	5.1801	2.14301
140	439.82	15393.8	19600	2744000	11.8322	5.1925	2.14613
141	442.96	15614.5	19881	2803221	11.8743	5.2048	2.14922
142	446.11	15836.8	20164	2863288	11.9164	5.2171	2.15229
143	449.25	16060.6	20449	2924207	11.9583	5.2293	2.15534
144	452.39	16286.0	20736	2985984	12.0000	5.2415	2.15836
145	455.53	16513.0	21025	3048625	12.0416	5.2536	2.16137
146	458.67	16741.5	21316	3112136	12.0830	5.2656	2.16435
147	461.81	16971.7	21609	3176523	12.1244	5.2776	2.16732
148	464.96	17203.4	21904	3241792	12.1655	5.2896	2.17026
149	468.10	17436.6	22201	3307949	12.2066	5.3015	2.17319

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
150	471.24	17671.5	22500	3375000	12.2474	5.3133	2.17609
151	474.38	17907.9	22801	3442951	12.2882	5.3251	2.17898
152	477.52	18145.8	23104	3511808	12.3288	5.3368	2.18184
153	480.66	18385.4	23409	3581577	12.3693	5.3485	2.18469
154	483.81	18626.5	23716	3652264	12.4097	5.3601	2.18752
155	486.95	18869.2	24025	3723875	12.4499	5.3717	2.19033
156	490.09	19113.4	24336	3796416	12.4900	5.3832	2.19312
157	493.23	19359.3	24649	3869893	12.5300	5.3947	2.19590
158	496.37	19606.7	24964	3944312	12.5698	5.4061	2.19866
159	499.51	19855.7	25281	4019679	12.6095	5.4175	2.20140
160	502.65	20106.2	25600	4096000	12.6491	5.4288	2.20412
161	505.80	20358.3	25921	4173281	12.6886	5.4401	2.20683
162	508.94	20612.0	26244	4251528	12.7279	5.4514	2.20952
163	512.08	20867.2	26569	4330747	12.7671	5.4626	2.21219
164	515.22	21124.1	26896	4410944	12.8062	5.4737	2.21484
165	518.36	21382.5	27225	4492125	12.8452	5.4848	2.21748
166	521.50	21642.4	27556	4574296	12.8841	5.4959	2.22011
167	524.65	21904.0	27889	4657463	12.9228	5.5069	2.22272
168	527.79	22167.1	28224	4741632	12.9615	5.5178	2.22531
169	530.93	22431.8	28561	4826809	13.0000	5.5288	2.22789
170	534.07	22698.0	28900	4913000	13.0384	5.5397	2.23045
171	537.21	22965.8	29241	5000211	13.0767	5.5505	2.23300
172	540.35	23235.2	29584	5088448	13.1149	5.5613	2.23553
173	543.50	23506.2	29929	5177717	13.1529	5.5721	2.23805
174	546.64	23778.7	30276	5268024	13.1909	5.5828	2.24055
175	549.78	24052.8	30625	5359375	13.2288	5.5934	2.24304
176	552.92	24328.5	30976	5451776	13.2665	5.6041	2.24551
177	556.06	24605.7	31329	5545233	13.3041	5.6147	2.24797
178	559.20	24884.6	31684	5639752	13.3417	5.6252	2.25042
179	562.35	25164.9	32041	5735339	13.3791	5.6357	2.25285
180	565.49	25446.9	32400	5832000	13.4164	5.6462	2.25527
181	568.63	25730.4	32761	5929741	13.4536	5.6567	2.25768
182	571.77	26015.5	33124	6028568	13.4907	5.6671	2.26007
183	574.91	26302.2	33489	6128487	13.5277	5.6774	2.26245
184	578.05	26590.4	33856	6229504	13.5647	5.6877	2.26482
185	581.19	26880.3	34225	6331625	13.6015	5.6980	2.26717
186	584.34	27171.6	34596	6434856	13.6382	5.7083	2.26951
187	587.48	27464.6	34969	6539203	13.6748	5.7185	2.27184
188	590.62	27759.1	35344	6644672	13.7113	5.7287	2.27416
189	593.76	28055.2	35721	6751269	13.7477	5.7388	2.27646
190	596.90	28352.9	36100	6859000	13.7840	5.7489	2.27875
191	600.04	28652.1	36481	6967871	13.8203	5.7590	2.28103
192	603.19	28952.9	36864	7077888	13.8564	5.7690	2.28330
193	606.33	29255.3	37249	7189057	13.8924	5.7790	2.28556
194	609.47	29559.2	37636	7301384	13.9284	5.7890	2.28780
195	612.61	29864.8	38025	7414875	13.9642	5.7989	2.29003
196	615.75	30171.9	38416	7529536	14.0000	5.8088	2.29226
197	618.89	30480.5	38809	7645373	14.0357	5.8186	2.29447
198	622.04	30790.7	39204	7762392	14.0712	5.8285	2.29667
199	625.18	31102.6	39601	7880599	14.1067	5.8383	2.29885

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
200	628.32	31415.9	40000	8000000	14.1421	5.8480	2.30103
201	631.46	31730.9	40401	8120601	14.1774	5.8578	2.30320
202	634.60	32047.4	40804	8242408	14.2127	5.8675	2.30535
203	637.74	32365.5	41209	8365427	14.2478	5.8771	2.30750
204	640.88	32685.1	41616	8489664	14.2829	5.8868	2.30963
205	644.03	33006.4	42025	8615125	14.3178	5.8964	2.31175
206	647.17	33329.2	42436	8741816	14.3527	5.9059	2.31387
207	650.31	33653.5	42849	8869743	14.3875	5.9155	2.31597
208	653.45	33979.5	43264	8998912	14.4222	5.9250	2.31806
209	656.59	34307.0	43681	9129329	14.4568	5.9345	2.32015
210	659.73	34636.1	44100	9261000	14.4914	5.9439	2.32222
211	662.88	34966.7	44521	9393931	14.5258	5.9533	2.32428
212	666.02	35298.9	44944	9528128	14.5602	5.9627	2.32634
213	669.16	35632.7	45369	9663597	14.5945	5.9721	2.32838
214	672.30	35968.1	45796	9800344	14.6287	5.9814	2.33041
215	675.44	36305.0	46225	9938375	14.6629	5.9907	2.33244
216	678.58	36643.5	46656	10077696	14.6969	6.0000	2.33445
217	681.73	36983.6	47089	10218313	14.7309	6.0092	2.33646
218	684.87	37325.3	47524	10360232	14.7648	6.0185	2.33846
219	688.01	37668.5	47961	10503459	14.7986	6.0277	2.34044
220	691.15	38013.3	48400	10648000	14.8324	6.0368	2.34242
221	694.29	38359.6	48841	10793861	14.8661	6.0459	2.34439
222	697.43	38707.6	49284	10941048	14.8997	6.0550	2.34635
223	700.58	39057.1	49729	11089567	14.9332	6.0641	2.34830
224	703.72	39408.1	50176	11239424	14.9666	6.0732	2.35025
225	706.86	39760.8	50625	11390625	15.0000	6.0822	2.35218
226	710.00	40115.0	51076	11543176	15.0333	6.0912	2.35411
227	713.14	40470.8	51529	11697083	15.0665	6.1002	2.35603
228	716.28	40828.1	51984	11852352	15.0997	6.1091	2.35793
229	719.42	41187.1	52441	12008989	15.1327	6.1180	2.35984
230	722.57	41547.6	52900	12167000	15.1658	6.1269	2.36173
231	725.71	41909.6	53361	12326391	15.1987	6.1358	2.36361
232	728.85	42273.3	53824	12487168	15.2315	6.1446	2.36549
233	731.99	42638.5	54289	12649337	15.2643	6.1534	2.36736
234	735.13	43005.3	54756	12812904	15.2971	6.1622	2.36922
235	738.27	43373.6	55225	12977875	15.3297	6.1710	2.37107
236	741.42	43743.5	55696	13144256	15.3623	6.1797	2.37291
237	744.56	44115.0	56169	13312053	15.3948	6.1885	2.37475
238	747.70	44488.1	56644	13481272	15.4272	6.1972	2.37658
239	750.84	44862.7	57121	13651919	15.4596	6.2058	2.37840
240	753.98	45238.9	57600	13824000	15.4919	6.2145	2.38021
241	757.12	45616.7	58081	13997521	15.5242	6.2231	2.38202
242	760.27	45996.1	58564	14172488	15.5563	6.2317	2.38382
243	763.41	46377.0	59049	14348907	15.5885	6.2403	2.38561
244	766.55	46759.5	59536	14526784	15.6205	6.2488	2.38739
245	769.69	47143.5	60025	14706125	15.6525	6.2573	2.38917
246	772.83	47529.2	60516	14886936	15.6844	6.2658	2.39094
247	775.97	47916.4	61009	15069223	15.7162	6.2743	2.39270
248	779.12	48305.1	61504	15252992	15.7480	6.2828	2.39445
249	782.26	48695.5	62001	15438249	15.7797	6.2912	2.39620

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
250	785.40	49087.4	62500	15625000	15.8114	6.2996	2.39794
251	788.54	49480.9	63001	15813251	15.8430	6.3080	2.39967
252	791.68	49875.9	63504	16003008	15.8745	6.3164	2.40140
253	794.82	50272.6	64009	16194277	15.9060	6.3247	2.40312
254	797.96	50670.7	64516	16387064	15.9374	6.3330	2.40483
255	801.11	51070.5	65025	16581375	15.9687	6.3413	2.40654
256	804.25	51471.9	65536	16777216	16.0000	6.3496	2.40824
257	807.39	51874.8	66049	16974593	16.0312	6.3579	2.40993
258	810.53	52279.2	66564	17173512	16.0624	6.3661	2.41162
259	813.67	52685.3	67081	17373979	16.0935	6.3743	2.41330
260	816.81	53092.9	67600	17576000	16.1245	6.3825	2.41497
261	819.96	53502.1	68121	17779581	16.1555	6.3907	2.41664
262	823.10	53912.9	68644	17984728	16.1864	6.3988	2.41830
263	826.24	54325.2	69169	18191447	16.2173	6.4070	2.41996
264	829.38	54739.1	69696	18399744	16.2481	6.4151	2.42160
265	832.52	55154.6	70225	18609625	16.2788	6.4232	2.42325
266	835.66	55571.6	70756	18821096	16.3095	6.4312	2.42488
267	838.81	55990.2	71289	19034163	16.3401	6.4393	2.42651
268	841.95	56410.4	71824	19248832	16.3707	6.4473	2.42813
269	845.09	56832.2	72361	19465109	16.4012	6.4553	2.42975
270	848.23	57255.5	72900	19683000	16.4317	6.4633	2.43136
271	851.37	57680.4	73441	19902511	16.4621	6.4713	2.43297
272	854.51	58106.9	73984	20123648	16.4924	6.4792	2.43457
273	857.65	58534.9	74529	20346417	16.5227	6.4872	2.43616
274	860.80	58964.6	75076	20570824	16.5529	6.4951	2.43775
275	863.94	59395.7	75625	20796875	16.5831	6.5030	2.43933
276	867.08	59828.5	76176	21024576	16.6132	6.5108	2.44091
277	870.22	60262.8	76729	21253933	16.6433	6.5187	2.44248
278	873.36	60698.7	77284	21484952	16.6733	6.5265	2.44404
279	876.50	61136.2	77841	21717639	16.7033	6.5343	2.44560
280	879.65	61575.2	78400	21952000	16.7332	6.5421	2.44716
281	882.79	62015.8	78961	22188041	16.7631	6.5499	2.44871
282	885.93	62458.0	79524	22425768	16.7929	6.5577	2.45025
283	889.07	62901.8	80089	22665187	16.8226	6.5654	2.45179
284	892.21	63347.1	80656	22906304	16.8523	6.5731	2.45332
285	895.35	63794.0	81225	23149125	16.8819	6.5808	2.45484
286	898.50	64242.4	81796	23393656	16.9115	6.5885	2.45637
287	901.64	64692.5	82369	23639903	16.9411	6.5962	2.45788
288	904.78	65144.1	82944	23887872	16.9706	6.6039	2.45939
289	907.92	65597.2	83521	24137569	17.0000	6.6115	2.46090
290	911.06	66052.0	84100	24389000	17.0294	6.6191	2.46240
291	914.20	66508.3	84681	24642171	17.0587	6.6267	2.46389
292	917.35	66966.2	85264	24897088	17.0880	6.6343	2.46538
293	920.49	67425.6	85849	25153757	17.1172	6.6419	2.46687
294	923.63	67886.7	86436	25412184	17.1464	6.6494	2.46835
295	926.77	68349.3	87025	25672375	17.1756	6.6569	2.46982
296	929.91	68813.4	87616	25934336	17.2047	6.6644	2.47129
297	933.05	69279.2	88209	26198073	17.2337	6.6719	2.47276
298	936.19	69746.5	88804	26463592	17.2627	6.6794	2.47422
299	939.34	70215.4	89401	26730899	17.2916	6.6869	2 47567

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
300	942.48	70685.8	90000	27000000	17.3205	6.6943	2.47712
301	945.62	71157.9	90601	27270901	17.3494	6.7018	2.47857
302	948.76	71631.5	91204	27543608	17.3781	6.7092	2.48001
303	951.90	72106.6	91809	27818127	17.4069	6.7166	2.48144
304	955.04	72583.4	92416	28094464	17.4356	6.7240	2.48287
305	958.19	73061.7	93025	28372625	17.4642	6.7313	2.48430
306	961.33	73541.5	93636	28652616	17.4929	6.7387	2.48572
307	964.47	74023.0	94249	28934443	17.5214	6.7460	2.48714
308	967.61	74506.0	94864	29218112	17.5499	6.7533	2.48855
309	970.75	74990.6	95481	29503629	17.5784	6.7606	2.48996
310	973.89	75476.8	96100	29791000	17.6068	6.7679	2.49136
311	977.04	75964.5	96721	30080231	17.6352	6.7752	2.49276
312	980.18	76453.8	97344	30371328	17.6635	6.7824	2.49415
313	983.32	76944.7	97969	30664297	17.6918	6.7897	2.49554
314	986.46	77437.1	98596	30959144	17.7200	6.7969	2.49693
315	989.60	77931.1	99225	31255875	17.7482	6.8041	2.49831
316	992.74	78426.7	99856	31554496	17.7764	6.8113	2.49969
317	995.88	78923.9	100489	31855013	17.8045	6.8185	2.50106
318	999.03	79422.6	101124	32157432	17.8326	6.8256	2.50243
319	1002.2	79922.9	101761	32461759	17.8606	6.8328	2.50379
320	1005.3	80424.8	102400	32768000	17.8885	6.8399	2.50515
321	1008.5	80928.2	103041	33076161	17.9165	6.8470	2.50651
322	1011.6	81433.2	103684	33386248	17.9444	6.8541	2.50786
323	1014.7	81939.8	104329	33698267	17.9722	6.8612	2.50920
324	1017.9	82448.0	104976	34012224	18.0000	6.8683	2.51055
325	1021.0	82957.7	105625	34328125	18.0278	6.8753	2.51188
326	1024.2	83469.0	106276	34645976	18.0555	6.8824	2.51322
327	1027.3	83981.8	106929	34965783	18.0831	6.8894	2.51455
328	1030.4	84496.3	107584	35287552	18.1108	6.8964	2.51587
329	1033.6	85012.3	108241	35611289	18.1384	6.9034	2.51720
330	1036.7	85529.9	108900	35937000	18.1659	6.9104	2.51851
331	1039.9	86049.0	109561	36264691	18.1934	6.9174	2.51983
332	1043.0	86569.7	110224	36594368	18.2209	6.9244	2.52114
333	1046.2	87092.0	110889	36926037	18.2483	6.9313	2.52244
334	1049.3	87615.9	111556	37259704	18.2757	6.9382	2.52375
335	1052.4	88141.3	112225	37595375	18.3030	6.9451	2.52504
336	1055.6	88668.3	112896	37933056	18.3303	6.9521	2.52634
337	1058.7	89196.9	113569	38272753	18.3576	6.9589	2.52763
338	1061.9	89727.0	114244	38614472	18.3848	6.9658	2.52892
339	1065.0	90258.7	114921	38958219	18.4120	6.9727	2.53020
340	1068.1	90792.0	115600	39304000	18.4391	6.9795	2.53148
341	1071.3	91326.9	116281	39651821	18.4662	6.9864	2.53275
342	1074.4	91863.3	116964	40001688	18.4932	6.9932	2.53403
343	1077.6	92401.3	117649	40353607	18.5203	7.0000	2.53529
344	1080.7	92940.9	118336	40707584	18.5472	7.0068	2.53656
345	1083.8	93482.0	119025	41063625	18.5742	7.0136	2.53782
346	1087.0	94024.7	119716	41421736	18.6011	7.0203	2.53908
347	1090.1	94569.0	120409	41781923	18.6279	7.0271	2.54033
348	1093.3	95114.9	121104	42144192	18.6548	7.0338	2.54158
349	1096.4	95662.3	121801	42508549	18.6815	7.0406	2.54283

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
350	1099.6	96211.3	122500	42875000	18.7083	7.0473	2.54407
351	1102.7	96761.8	123201	43243551	18.7350	7.0540	2.54531
352	1105.8	97314.0	123904	43614208	18.7617	7.0607	2.54654
353	1109.0	97867.7	124609	43986977	18.7883	7.0674	2.54777
354	1112.1	98423.0	125316	44361864	18.8149	7.0740	2.54900
355	1115.3	98979.8	126025	44738875	18.8414	7.0807	2.55023
356	1118.4	99538.2	126736	45118016	18.8680	7.0873	2.55145
357	1121.5	100098	127449	45499293	18.8944	7.0940	2.55267
358	1124.7	100660	128164	45882712	18.9209	7.1006	2.55388
359	1127.8	101223	128881	46268279	18.9473	7.1072	2.55509
360	1131.0	101788	129600	46656000	18.9737	7.1138	2.55630
361	1134.1	102354	130321	47045881	19.0000	7.1204	2.55751
362	1137.3	102922	131044	47437928	19.0263	7.1269	2.55871
363	1140.4	103491	131769	47832147	19.0526	7.1335	2.55991
364	1143.5	104062	132496	48228544	19.0788	7.1400	2.56110
365	1146.7	104635	133225	48627125	19.1050	7.1466	2.56229
366	1149.8	105209	133956	49027896	19.1311	7.1531	2.56348
367	1153.0	105785	134689	49430863	19.1572	7.1596	2.56467
368	1156.1	106362	135424	49836032	19.1833	7.1661	2.56585
369	1159.2	106941	136161	50243409	19.2094	7.1726	2.56703
370	1162.4	107521	136900	50653000	19.2354	7.1791	2.56820
371	1165.5	108103	137641	51064811	19.2614	7.1855	2.56937
372	1168.7	108687	138384	51478848	19.2873	7.1920	2.57054
373	1171.8	109272	139129	51895117	19.3132	7.1984	2.57171
374	1175.0	109858	139876	52313624	19.3391	7.2048	2.57287
375	1178.1	110447	140625	52734375	19.3649	7.2112	2.57403
376	1181.2	111036	141376	53157376	19.3907	7.2177	2.57519
377	1184.4	111628	142129	53582633	19.4165	7.2240	2.57634
378	1187.5	112221	142884	54010152	19.4422	7.2304	2.57749
379	1190.7	112815	143641	54439939	19.4679	7.2368	2.57864
380	1193.8	113411	144400	54872000	19.4936	7.2432	2.57978
381	1196.9	114009	145161	55306341	19.5192	7.2495	2.58093
382	1200.1	114608	145924	55742968	19.5448	7.2558	2.58206
383	1203.2	115209	146689	56181887	19.5704	7.2622	2.58320
384	1206.4	115812	147456	56623104	19.5959	7.2685	2.58433
385	1209.5	116416	148225	57066625	19.6214	7.2748	2.58546
386	1212.7	117021	148996	57512456	19.6469	7.2811	2.58659
387	1215.8	117628	149769	57960603	19.6723	7.2874	2.58771
388	1218.9	118237	150544	58411072	19.6977	7.2936	2.58883
389	1222.1	118847	151321	58863869	19.7231	7.2999	2.58995
390	1225.2	119459	152100	59319000	19.7484	7.3061	2.59106
391	1228.4	120072	152881	59776471	19.7737	7.3124	2.59218
392	1231.5	120687	153664	60236288	19.7990	7.3186	2.59329
393	1234.6	121304	154449	60698457	19.8242	7.3248	2.59439
394	1237.8	121922	155236	61162984	19.8494	7.3310	2.59550
395	1240.9	122542	156025	61629875	19.8746	7.3372	2.59660
396	1244.1	123163	156816	62099136	19.8997	7.3434	2.59770
397	1247.2	123786	157609	62570773	19.9249	7.3496	2.59879
398	1250.4	124410	158404	63044792	19.9499	7.3558	2.59988
399	1253.5	125036	159201	63521199	19.9750	7.3619	2.60097

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
400	1256.6	125664	160000	64000000	20.0000	7.3681	2.60206
401	1259.8	126293	160801	64481201	20.0250	7.3742	2.60314
402	1262.9	126923	161604	64964808	20.0499	7.3803	2.60423
403	1266.1	127556	162409	65450827	20.0749	7.3864	2.60531
404	1269.2	128190	163216	65939264	20.0998	7.3925	2.60638
405	1272.3	128825	164025	66430125	20.1246	7.3986	2.60746
406	1275.5	129462	164836	66923416	20.1494	7.4047	2.60853
407	1278.6	130100	165649	67419143	20.1742	7.4108	2.60959
408	1281.8	130741	166464	67917312	20.1990	7.4169	2.61066
409	1284.9	131382	167281	68417929	20.2237	7.4229	2.61172
410	1288.1	132025	168100	68921000	20.2485	7.4290	2.61278
411	1291.2	132670	168921	69426531	20.2731	7.4350	2.61384
412	1294.3	133317	169744	69934528	20.2978	7.4410	2.61490
413	1297.5	133965	170569	70444997	20.3224	7.4470	2.61595
414	1300.6	134614	171396	70957944	20.3470	7.4530	2.61700
415	1303.8	135265	172225	71473375	20.3715	7.4590	2.61805
416	1306.9	135918	173056	71991296	20.3961	7.4650	2.61909
417	1310.0	136572	173889	72511713	20.4206	7.4710	2.62014
418	1313.2	137228	174724	73034632	20.4450	7.4770	2.62118
419	1316.3	137885	175561	73560059	20.4695	7.4829	2.62221
420	1319.5	138544	176400	74088000	20.4939	7.4889	2.62325
421	1322.6	139205	177241	74618461	20.5183	7.4948	2.62428
422	1325.8	139867	178084	75151448	20.5426	7.5007	2.62531
423	1328.9	140531	178929	75686967	20.5670	7.5067	2.62634
424	1332.0	141196	179776	76225024	20.5913	7.5126	2.62737
425	1335.2	141863	180625	76765625	20.6155	7.5185	2.62839
426	1338.3	142531	181476	77308776	20.6398	7.5244	2.62941
427	1341.5	143201	182329	77854483	20.6640	7.5302	2.63043
428	1344.6	143872	183184	78402752	20.6882	7.5361	2.63144
429	1347.7	144545	184041	78953589	20.7123	7.5420	2.63246
430	1350.9	145220	184900	79507000	20.7364	7.5478	2.63347
431	1354.0	145896	185761	80062991	20.7605	7.5537	2.63448
432	1357.2	146574	186624	80621568	20.7846	7.5595	2.63548
433	1360.3	147254	187489	81182737	20.8087	7.5654	2.63649
434	1363.5	147934	188356	81746504	20.8327	7.5712	2.63749
435	1366.6	148617	189225	82312875	20.8567	7.5770	2.63849
436	1369.7	149301	190096	82881856	20.8806	7.5828	2.63949
437	1372.9	149987	190969	83453453	20.9045	7.5886	2.64048
438	1376.0	150674	191844	84027672	20.9284	7.5944	2.64147
439	1379.2	151363	192721	84604519	20.9523	7.6001	2.64246
440	1382.3	152053	193600	85184000	20.9762	7.6059	2.64345
441	1385.4	152745	194481	85766121	21.0000	7.6117	2.64444
442	1388.6	153439	195364	86350888	21.0238	7.6174	2.64542
443	1391.7	154134	196249	86938307	21.0476	7.6232	2.64640
444	1394.9	154830	197136	87528384	21.0713	7.6289	2.64738
445	1398.0	155528	198025	88121125	21.0950	7.6346	2.64836
446	1401.2	156228	198916	88716536	21.1187	7.6403	2.64933
447	1404.3	156930	199809	89314623	21.1424	7.6460	2.65031
448	1407.4	157633	200704	89915392	21.1660	7.6517	2.65128
449	1410.6	158337	201601	90518849	21.1896	7.6574	2.65225

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
450	1413.7	159043	202500	91125000	21.2132	7.6631	2.65321
451	1416.9	159751	203401	91733851	21.2368	7.6688	2.65418
452	1420.0	160460	204304	92345408	21.2603	7.6744	2.65514
453	1423.1	161171	205209	92959677	21.2838	7.6801	2.65610
454	1426.3	161883	206116	93576664	21.3073	7.6857	2.65706
455	1429.4	162597	207025	94196375	21.3307	7.6914	2.65801
456	1432.6	163313	207936	94818816	21.3542	7.6970	2.65896
457	1435.7	164030	208849	95443993	21.3776	7.7026	2.65992
458	1438.8	164748	209764	96071912	21.4009	7.7082	2.66087
459	1442.0	165468	210681	96702579	21.4243	7.7138	2.66181
460	1445.1	166190	211600	97336000	21.4476	7.7194	2.66276
461	1448.3	166914	212521	97972181	21.4709	7.7250	2.66370
462	1451.4	167639	213444	98611128	21.4942	7.7306	2.66464
463	1454.6	168365	214369	99252847	21.5174	7.7362	2.66558
464	1457.7	169093	215296	99897344	21.5407	7.7418	2.66652
465	1460.8	169823	216225	100544625	21.5639	7.7473	2.66745
466	1464.0	170554	217156	101194696	21.5870	7.7529	2.66839
467	1467.1	171287	218089	101847563	21.6102	7.7584	2.66932
468	1470.3	172021	219024	102503232	21.6333	7.7639	2.67025
469	1473.4	172757	219961	103161709	21.6564	7.7695	2.67117
470	1476.5	173494	220900	103823000	21.6795	7.7750	2.67210
471	1479.7	174234	221841	104487111	21.7025	7.7805	2.67302
472	1482.8	174974	222784	105154048	21.7256	7.7860	2.67394
473	1486.0	175716	223729	105823817	21.7486	7.7915	2.67486
474	1489.1	176460	224676	106496424	21.7715	7.7970	2.67578
475	1492.3	177205	225625	107171875	21.7945	7.8025	2.67669
476	1495.4	177952	226576	107850176	21.8174	7.8079	2.67761
477	1498.5	178701	227529	108531333	21.8403	7.8134	2.67852
478	1501.7	179451	228484	109215352	21.8632	7.8188	2.67943
479	1504.8	180203	229441	109902239	21.8861	7.8243	2.68034
480	1508.0	180956	230400	110592000	21.9089	7.8297	2.68124
481	1511.1	181711	231361	111284641	21.9317	7.8352	2.68215
482	1514.2	182467	232324	111980168	21.9545	7.8406	2.68305
483	1517.4	183225	233289	112678587	21.9773	7.8460	2.68395
484	1520.5	183984	234256	113379904	22.0000	7.8514	2.68485
485	1523.7	184745	235225	114084125	22.0227	7.8568	2.68574
486	1526.8	185508	236196	114791256	22.0454	7.8622	2.68664
487	1530.0	186272	237169	115501303	22.0681	7.8676	2.68753
488	1533.1	187038	238144	116214272	22.0907	7.8730	2.68842
489	1536.2	187805	239121	116930169	22.1133	7.8784	2.68931
490	1539.4	188574	240100	117649000	22.1359	7.8837	2.69020
491	1542.5	189345	241081	118370771	22.1585	7.8891	2.69108
492	1545.7	190117	242064	119095488	22.1811	7.8944	2.69197
493	1548.8	190890	243049	119823157	22.2036	7.8998	2.69285
494	1551.9	191665	244036	120553784	22.2261	7.9051	2.69373
495	1555.1	192442	245025	121287375	22.2486	7.9105	2.69461
496	1558.2	193221	246016	122023936	22.2711	7.9158	2.69548
497	1561.4	194000	247009	122763473	22.2935	7.9211	2.69636
498	1564.5	194782	248004	123505992	22.3159	7.9264	2.69723
499	1567.7	195565	249001	124251499	22.3383	7.9317	2.69810

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
500	1570.8	196350	250000	125000000	22.3607	7.9370	2.69897
501	1573.9	197136	251001	125751501	22.3830	7.9423	2.69984
502	1577.1	197923	252004	126506008	22.4054	7.9476	2.70070
503	1580.2	198713	253009	127263527	22.4277	7.9528	2.70157
504	1583.4	199504	254016	128024064	22.4499	7.9581	2.70243
505	1586.5	200296	255025	128787625	22.4722	7.9634	2.70329
506	1589.6	201090	256036	129554216	22.4944	7.9686	2.70415
507	1592.8	201886	257049	130323843	22.5167	7.9739	2.70501
508	1595.9	202683	258064	131096512	22.5389	7.9791	2.70586
509	1599.1	203482	259081	131872229	22.5610	7.9843	2.70672
510	1602.2	204282	260100	132651000	22.5832	7.9896	2.70757
511	1605.4	205084	261121	133432831	22.6053	7.9948	2.70842
512	1608.5	205887	262144	134217728	22.6274	8.0000	2.70927
513	1611.6	206692	263169	135005697	22.6495	8.0052	2.71012
514	1614.8	207499	264196	135796744	22.6716	8.0104	2.71096
515	1617.9	208307	265225	136590875	22.6936	8.0156	2.71181
516	1621.1	209117	266256	137388096	22.7156	8.0208	2.71265
517	1624.2	209928	267289	138188413	22.7376	8.0260	2.71349
518	1627.3	210741	268324	138991832	22.7596	8.0311	2.71433
519	1630.5	211556	269361	139798359	22.7816	8.0363	2.71517
520	1633.6	212372	270400	140608000	22.8035	8.0415	2.71600
521	1636.8	213189	271441	141420761	22.8254	8.0466	2.71684
522	1639.9	214008	272484	142236648	22.8473	8.0517	2.71767
523	1643.1	214829	273529	143055667	22.8692	8.0569	2.71850
524	1646.2	215651	274576	143877824	22.8910	8.0620	2.71933
525	1649.3	216475	275625	144703125	22.9129	8.0671	2.72016
526	1652.5	217301	276676	145531576	22.9347	8.0723	2.72099
527	1655.6	218128	277729	146363183	22.9565	8.0774	2.72181
528	1658.8	218956	278784	147197952	22.9783	8.0825	2.72263
529	1661.9	219787	279841	148035889	23.0000	8.0876	2.72346
530	1665.0	220618	280900	148877000	23.0217	8.0927	2.72428
531	1668.2	221452	281961	149721291	23.0434	8.0978	2.72509
532	1671.3	222287	283024	150568768	23.0651	8.1028	2.72591
533	1674.5	223123	284089	151419437	23.0868	8.1079	2.72673
534	1677.6	223961	285156	152273304	23.1084	8.1130	2.72754
535	1680.8	224801	286225	153130375	23.1301	8.1180	2.72835
536	1683.9	225642	287296	153990656	23.1517	8.1231	2.72916
537	1687.0	226484	288369	154854153	23.1733	8.1281	2.72997
538	1690.2	227329	289444	155720872	23.1948	8.1332	2.73078
539	1693.3	228175	290521	156590819	23.2164	8.1382	2.73159
540	1696.5	229022	291600	157464000	23.2379	8.1433	2.73239
541	1699.6	229871	292681	158340421	23.2594	8.1483	2.73320
542	1702.7	230722	293764	159220088	23.2809	8.1533	2.73400
543	1705.9	231574	294849	160103007	23.3024	8.1583	2.73480
544	1709.0	232428	295936	160989184	23.3238	8.1633	2.73560
545	1712.2	233283	297025	161878625	23.3452	8.1683	2.73640
546	1715.3	234140	298116	162771336	23.3666	8.1733	2.73719
547	1718.5	234998	299209	163667323	23.3880	8.1783	2.73799
548	1721.6	235858	300304	164566592	23.4094	8.1833	2.73878
549	1724.7	236720	301401	165469149	23.4307	8.1882	2.73957

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
550	1727.9	237583	302500	166375000	23.4521	8.1932	2.74036
551	1731.0	238448	303601	167284151	23.4734	8.1982	2.74115
552	1734.2	239314	304704	168196608	23.4947	8.2031	2.74194
553	1737.3	240182	305809	169112377	23.5160	8.2081	2.74273
554	1740.4	241051	306916	170031464	23.5372	8.2130	2.74351
555	1743.6	241922	308025	170953875	23.5584	8.2180	2.74429
556	1746.7	242795	309136	171879616	23.5797	8.2229	2.74507
557	1749.9	243669	310249	172808693	23.6008	8.2278	2.74586
558	1753.0	244545	311364	173741112	23.6220	8.2327	2.74663
559	1756.2	245422	312481	174676879	23.6432	8.2377	2.74741
560	1759.3	246301	313600	175616000	23.6643	8.2426	2.74819
561	1762.4	247181	314721	176558481	23.6854	8.2475	2.74896
562	1765.6	248063	315844	177504328	23.7065	8.2524	2.74974
563	1768.7	248947	316969	178453547	23.7276	8.2573	2.75051
564	1771.9	249832	318096	179406144	23.7487	8.2621	2.75128
565	1775.0	250719	319225	180362125	23.7697	8.2670	2.75205
566	1778.1	251607	320356	181321496	23.7908	8.2719	2.75282
567	1781.3	252497	321489	182284263	23.8118	8.2768	2.75358
568	1784.4	253388	322624	183250432	23.8328	8.2816	2.75435
569	1787.6	254281	323761	184220009	23.8537	8.2865	2.75511
570	1790.7	255176	324900	185193000	23.8747	8.2913	2.75587
571	1793.8	256072	326041	186169411	23.8956	8.2962	2.75664
572	1797.0	256970	327184	187149248	23.9165	8.3010	2.75740
573	1800.1	257869	328329	188132517	23.9374	8.3059	2.75815
574	1803.3	258770	329476	189119224	23.9583	8.3107	2.75891
575	1806.4	259672	330625	190109375	23.9792	8.3155	2.75967
576	1809.6	260576	331776	191102976	24.0000	8.3203	2.76042
577	1812.7	261482	332929	192100033	24.0208	8.3251	2.76118
578	1815.8	262389	334084	193100552	24.0416	8.3300	2.76193
579	1819.0	263298	335241	194104539	24.0624	8.3348	2.76268
580	1822.1	264208	336400	195112000	24.0832	8.3396	2.76343
581	1825.3	265120	337561	196122941	24.1039	8.3443	2.76418
582	1828.4	266033	338724	197137368	24.1247	8.3491	2.76492
583	1831.6	266948	339889	198155287	24.1454	8.3539	2.76567
584	1834.7	267865	341056	199176704	24.1661	8.3587	2.76641
585	1837.8	268783	342225	200201625	24.1868	8.3634	2.76716
586	1841.0	269703	343396	201230056	24.2074	8.3682	2.76790
587	1844.1	270624	344569	202262003	24.2281	8.3730	2.76864
588	1847.3	271547	345744	203297472	24.2487	8.3777	2.76938
589	1850.4	272471	346921	204336469	24.2693	8.3825	2.77012
590	1853.5	273397	348100	205379000	24.2899	8.3872	2.77085
591	1856.7	274325	349281	206425071	24.3105	8.3919	2.77159
592	1859.8	275254	350464	207474688	24.3311	8.3967	2.77232
593	1863.0	276184	351649	208527857	24.3516	8.4014	2.77305
594	1866.1	277117	352836	209584584	24.3721	8.4061	2.77379
595	1869.2	278051	354025	210644875	24.3926	8.4108	2.77452
596	1872.4	278986	355216	211708736	24.4131	8.4155	2.77525
597	1875.5	279923	356409	212776173	24.4336	8.4202	2.77597
598	1878.7	280862	357604	213847192	24.4540	8.4249	2.77670
599	1881.8	281802	358801	214921799	24.4745	8.4296	2.77743

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
600	1885.0	282743	360000	216000000	24.4949	8.4343	2.77815
601	1888.1	283687	361201	217081801	24.5153	8.4390	2.77887
602	1891.2	284631	362404	218167208	24.5357	8.4437	2.77960
603	1894.4	285578	363609	219256227	24.5561	8.4484	2.78032
604	1897.5	286526	364816	220348864	24.5764	8.4530	2.78104
605	1900.7	287475	366025	221445125	24.5967	8.4577	2.78176
606	1903.8	288426	367236	222545016	24.6171	8.4623	2.78247
607	1906.9	289379	368449	223648543	24.6374	8.4670	2.78319
608	1910.1	290333	369664	224755712	24.6577	8.4716	2.78390
609	1913.2	291289	370881	225866529	24.6779	8.4763	2.78462
610	1916.4	292247	372100	226981000	24.6982	8.4809	2.78533
611	1919.5	293206	373321	228099131	24.7184	8.4856	2.78604
612	1922.7	294166	374544	229220928	24.7386	8.4902	2.78675
613	1925.8	295128	375769	230346397	24.7588	8.4948	2.78746
614	1928.9	296092	376996	231475544	24.7790	8.4994	2.78817
615	1932.1	297057	378225	232608375	24.7992	8.5040	2.78888
616	1935.2	298024	379456	233744896	24.8193	8.5086	2.78958
617	1938.4	298992	380689	234885113	24.8395	8.5132	2.79029
618	1941.5	299962	381924	236029032	24.8596	8.5178	2.79099
619	1944.6	300934	383161	237176659	24.8797	8.5224	2.79169
620	1947.8	301907	384400	238328000	24.8998	8.5270	2.79239
621	1950.9	302882	385641	239483061	24.9199	8.5316	2.79309
622	1954.1	303858	386884	240641848	24.9399	8.5362	2.79379
623	1957.2	304836	388129	241804367	24.9600	8.5408	2.79449
624	1960.4	305815	389376	242970624	24.9800	8.5453	2.79518
625	1963.5	306796	390625	244140625	25.0000	8.5499	2.79588
626	1966.6	307779	391876	245314376	25.0200	8.5544	2.79657
627	1969.8	308763	393129	246491883	25.0400	8.5590	2.79727
628	1972.9	309748	394384	247673152	25.0599	8.5635	2.79796
629	1976.1	310736	395641	248858189	25.0799	8.5681	2.79865
630	1979.2	311725	396900	250047000	25.0998	8.5726	2.79934
631	1982.3	312715	398161	251239591	25.1197	8.5772	2.80003
632	1985.5	313707	399424	252435968	25.1396	8.5817	2.80072
633	1988.6	314700	400689	253636137	25.1595	8.5862	2.80140
634	1991.8	315696	401956	254840104	25.1794	8.5907	2.80209
635	1994.9	316692	403225	256047875	25.1992	8.5952	2.80277
636	1998.1	317690	404496	257259456	25.2190	8.5997	2.80346
637	2001.2	318690	405769	258474853	25.2389	8.6043	2.80414
638	2004.3	319692	407044	259694072	25.2587	8.6088	2.80482
639	2007.5	320695	408321	260917119	25.2784	8.6132	2.80550
640	2010.6	321699	409600	262144000	25.2982	8.6177	2.80618
641	2013.8	322705	410881	263374721	25.3180	8.6222	2.80686
642	2016.9	323713	412164	264609288	25.3377	8.6267	2.80754
643	2020.0	324722	413449	265847707	25.3574	8.6312	2.80821
644	2023.2	325733	414736	267089984	25.3772	8.6357	2.80889
645	2026.3	326745	416025	268336125	25.3969	8.6401	2.80956
646	2029.5	327759	417316	269586136	25.4165	8.6446	2.81023
647	2032.6	328775	418609	270840023	25.4362	8.6490	2.81090
648	2035.8	329792	419904	272097792	25.4558	8.6535	2.81158
649	2038.9	330810	421201	273359449	25.4755	8.6579	2.81224

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
650	2042.0	331831	422500	274625000	25.4951	8.6624	2.81291
651	2045.2	332853	423801	275894451	25.5147	8.6668	2.81358
652	2048.3	333876	425104	277167808	25.5343	8.6713	2.81425
653	2051.5	334901	426409	278445077	25.5539	8.6757	2.81491
654	2054.6	335927	427716	279726264	25.5734	8.6801	2.81558
655	2057.7	336955	429025	281011375	25.5930	8.6845	2.81624
656	2060.9	337985	430336	282300416	25.6125	8.6890	2.81690
657	2064.0	339016	431649	283593393	25.6320	8.6934	2.81757
658	2067.2	340049	432964	284890312	25.6515	8.6978	2.81823
659	2070.3	341084	434281	286191179	25.6710	8.7022	2.81889
660	2073.5	342119	435600	287496000	25.6905	8.7066	2.81954
661	2076.6	343157	436921	288804781	25.7099	8.7110	2.82020
662	2079.7	344196	438244	290117528	25.7294	8.7154	2.82086
663	2082.9	345237	439569	291434247	25.7488	8.7198	2.82151
664	2086.0	346279	440896	292754944	25.7682	8.7241	2.82217
665	2089.2	347323	442225	294079625	25.7876	8.7285	2.82282
666	2092.3	348368	443556	295408296	25.8070	8.7329	2.82347
667	2095.4	349415	444889	296740963	25.8263	8.7373	2.82413
668	2098.6	350464	446224	298077632	25.8457	8.7416	2.82478
669	2101.7	351514	447561	299418309	25.8650	8.7460	2.82543
670	2104.9	352565	448900	300763000	25.8844	8.7503	2.82607
671	2108.0	353618	450241	302111711	25.9037	8.7547	2.82672
672	2111.2	354673	451584	303464448	25.9230	8.7590	2.82737
673	2114.3	355730	452929	304821217	25.9422	8.7634	2.82802
674	2117.4	356788	454276	306182024	25.9615	8.7677	2.82866
675	2120.6	357847	455625	307546875	25.9808	8.7721	2.82930
676	2123.7	358908	456976	308915776	26.0000	8.7764	2.82995
677	2126.9	359971	458329	310288733	26.0192	8.7807	2.83059
678	2130.0	361035	459684	311665752	26.0384	8.7850	2.83123
679	2133.1	362101	461041	313046839	26.0576	8.7893	2.83187
680	2136.3	363168	462400	314432000	26.0768	8.7937	2.83251
681	2139.4	364237	463761	315821241	26.0960	8.7980	2.83315
682	2142.6	365308	465124	317214568	26.1151	8.8023	2.83378
683	2145.7	366380	466489	318611987	26.1343	8.8066	2.83442
684	2148.8	367453	467856	320013504	26.1534	8.8109	2.83506
685	2152.0	368528	469225	321419125	26.1725	8.8152	2.83569
686	2155.1	369605	470596	322828856	26.1916	8.8194	2.83632
687	2158.3	370684	471969	324242703	26.2107	8.8237	2.83696
688	2161.4	371764	473344	325660672	26.2298	8.8280	2.83759
689	2164.6	372845	474721	327082769	26.2488	8.8323	2.83822
690	2167.7	373928	476100	328509000	26.2679	8.8366	2.83885
691	2170.8	375013	477481	329939371	26.2869	8.8408	2.83948
692	2174.0	376099	478864	331373888	26.3059	8.8451	2.84011
693	2177.1	377187	480249	332812557	26.3249	8.8493	2.84073
694	2180.3	378276	481636	334255384	26.3439	8.8536	2.84136
695	2183.4	379367	483025	335702375	26.3629	8.8578	2.84198
696	2186.5	380459	484416	337153536	26.3818	8.8621	2.84261
697	2189.7	381553	485809	338608873	26.4008	8.8663	2.84323
698	2192.8	382649	487204	340068392	26.4197	8.8706	2.84386
699	2196.0	383746	488601	341532099	26.4386	8.8748	2.84448

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
700	2199.1	384845	490000	343000000	26.4575	8.8790	2.84510
701	2202.3	385945	491401	344472101	26.4764	8.8833	2.84572
702	2205.4	387047	492804	345948408	26.4953	8.8875	2.84634
703	2208.5	388151	494209	347428927	26.5141	8.8917	2.84696
704	2211.7	389256	495616	348913664	26.5330	8.8959	2.84757
705	2214.8	390363	497025	350402625	26.5518	8.9001	2.84819
706	2218.0	391471	498436	351895816	26.5707	8.9043	2.84880
707	2221.1	392580	499849	353393243	26.5895	8.9085	2.84942
708	2224.2	393692	501264	354894912	26.6083	8.9127	2.85003
709	2227.4	394805	502681	356400829	26.6271	8.9169	2.85065
710	2230.5	395919	504100	357911000	26.6458	8.9211	2.85126
711	2233.7	397035	505521	359425431	26.6646	8.9253	2.85187
712	2236.8	398153	506944	360944128	26.6833	8.9295	2.85248
713	2240.0	399272	508369	362467097	26.7021	8.9337	2.85309
714	2243.1	400393	509796	363994344	26.7208	8.9378	2.85370
715	2246.2	401515	511225	365525875	26.7395	8.9420	2.85431
716	2249.4	402639	512656	367061696	26.7582	8.9462	2.85491
717	2252.5	403765	514089	368601813	26.7769	8.9503	2.85552
718	2255.7	404892	515524	370146232	26.7955	8.9545	2.85612
719	2258.8	406020	516961	371694959	26.8142	8.9587	2.85673
720	2261.9	407150	518400	373248000	26.8328	8.9628	2.85733
721	2265.1	408282	519841	374805361	26.8514	8.9670	2.85794
722	2268.2	409415	521284	376367048	26.8701	8.9711	2.85854
723	2271.4	410550	522729	377933067	26.8887	8.9752	2.85914
724	2274.5	411687	524176	379503424	26.9072	8.9794	2.85974
725	2277.7	412825	525625	381078125	26.9258	8.9835	2.86034
726	2280.8	413965	527076	382657176	26.9444	8.9876	2.86094
727	2283.9	415106	528529	384240583	26.9629	8.9918	2.86153
728	2287.1	416248	529984	385828352	26.9815	8.9959	2.86213
729	2290.2	417393	531441	387420489	27.0000	9.0000	2.86273
730	2293.4	418539	532900	389017000	27.0185	9.0041	2.86332
731	2296.5	419686	534361	390617891	27.0370	9.0082	2.86392
732	2299.6	420835	535824	392223168	27.0555	9.0123	2.86451
733	2302.8	421986	537289	393832837	27.0740	9.0164	2.86510
734	2305.9	423138	538756	395446904	27.0924	9.0205	2.86570
735	2309.1	424293	540225	397065375	27.1109	9.0246	2.86629
736	2312.2	425447	541696	398688256	27.1293	9.0287	2.86688
737	2315.4	426604	543169	400315553	27.1477	9.0328	2.86747
738	2318.5	427762	544644	401947272	27.1662	9.0369	2.86806
739	2321.6	428922	546121	403583419	27.1846	9.0410	2.86864
740	2324.8	430084	547600	405224000	27.2029	9.0450	2.86923
741	2327.9	431247	549081	406869021	27.2213	9.0491	2.86982
742	2331.1	432412	550564	408518488	27.2397	9.0532	2.87040
743	2334.2	433578	552049	410172407	27.2580	9.0572	2.87099
744	2337.3	434746	553536	411830784	27.2764	9.0613	2.87157
745	2340.5	435916	555025	413493625	27.2947	9.0654	2.87216
746	2343.6	437087	556516	415160936	27.3130	9.0694	2.87274
747	2346.8	438259	558009	416832723	27.3313	9.0735	2.87332
748	2349.9	439433	559504	418508992	27.3496	9.0775	2.87390
749	2353.1	440609	561001	420189749	27.3679	9.0816	2.87448

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
750	2356.2	441786	562500	421875000	27.3861	9.0856	2.87506
751	2359.3	442965	564001	423564751	27.4044	9.0896	2.87564
752	2362.5	444146	565504	425259008	27.4226	9.0937	2.87622
753	2365.6	445328	567009	426957777	27.4408	9.0977	2.87680
754	2368.8	446511	568516	428661064	27.4591	9.1017	2.87737
755	2371.9	447697	570025	430368875	27.4773	9.1057	2.87795
756	2375.0	448883	571536	432081216	27.4955	9.1098	2.87852
757	2378.2	450072	573049	433798093	27.5136	9.1138	2.87910
758	2381.3	451262	574564	435519512	27.5318	9.1178	2.87967
759	2384.5	452453	576081	437245479	27.5500	9.1218	2.88024
760	2387.6	453646	577600	438976000	27.5681	9.1258	2.88081
761	2390.8	454841	579121	440711081	27.5862	9.1298	2.88138
762	2393.9	456037	580644	442450728	27.6043	9.1338	2.88196
763	2397.0	457234	582169	444194947	27.6225	9.1378	2.88252
764	2400.2	458434	583696	445943744	27.6405	9.1418	2.88309
765	2403.3	459635	585225	447697125	27.6586	9.1458	2.88366
766	2406.5	460837	586756	449455096	27.6767	9.1498	2.88423
767	2409.6	462041	588289	451217663	27.6948	9.1537	2.88480
768	2412.7	463247	589824	452984832	27.7128	9.1577	2.88536
769	2415.9	464454	591361	454756609	27.7308	9.1617	2.88593
770	2419.0	465663	592900	456533000	27.7489	9.1657	2.88649
771	2422.2	466873	594441	458314011	27.7669	9.1696	2.88705
772	2425.3	468085	595984	460099648	27.7849	9.1736	2.88762
773	2428.5	469298	597529	461889917	27.8029	9.1775	2.88818
774	2431.6	470513	599076	463684824	27.8209	9.1815	2.88874
775	2434.7	471730	600625	465484375	27.8388	9.1855	2.88930
776	2437.9	472948	602176	467288576	27.8568	9.1894	2.88986
777	2441.0	474168	603729	469097433	27.8747	9.1933	2.89042
778	2444.2	475389	605284	470910952	27.8927	9.1973	2.89098
779	2447.3	476612	606841	472729139	27.9106	9.2012	2.89154
780	2450.4	477836	608400	474552000	27.9285	9.2052	2.89209
781	2453.6	479062	609961	476379541	27.9464	9.2091	2.89265
782	2456.7	480290	611524	478211768	27.9643	9.2130	2.89321
783	2459.9	481519	613089	480048687	27.9821	9.2170	2.89376
784	2463.0	482750	614656	481890304	28.0000	9.2209	2.89432
785	2466.2	483982	616225	483736625	28.0179	9.2248	2.89487
786	2469.3	485216	617796	485587656	28.0357	9.2287	2.89542
787	2472.4	486451	619369	487443403	28.0535	9.2326	2.89597
788	2475.6	487688	620944	489303872	28.0713	9.2365	2.89653
789	2478.7	488927	622521	491169069	28.0891	9.2404	2.89708
790	2481.9	490167	624100	493039000	28.1069	9.2443	2.89763
791	2485.0	491409	625681	494913671	28.1247	9.2482	2.89818
792	2488.1	492652	627264	496793088	28.1425	9.2521	2.89873
793	2491.3	493897	628849	498677257	28.1603	9.2560	2.89927
794	2494.4	495143	630436	500566184	28.1780	9.2599	2.89982
795	2497.6	496391	632025	502459875	28.1957	9.2638	2.90037
796	2500.7	497641	633616	504358336	28.2135	9.2677	2.90091
797	2503.8	498892	635209	506261573	28.2312	9.2716	2.90146
798	2507.0	500145	636804	508169592	28.2489	9.2754	2.90200
799	2510.1	501399	638401	510082399	28.2666	9.2793	2.90255

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
800	2513.3	502655	640000	512000000	28.2843	9.2832	2.90309
801	2516.4	503912	641601	513922401	28.3019	9.2870	2.90363
802	2519.6	505171	643204	515849608	28.3196	9.2909	2.90417
803	2522.7	506432	644809	517781627	28.3373	9.2948	2.90472
804	2525.8	507694	646416	519718464	28.3549	9.2986	2.90526
805	2529.0	508958	648025	521660125	28.3725	9.3025	2.90580
806	2532.1	510223	649636	523606616	28.3901	9.3063	2.90634
807	2535.3	511490	651249	525557943	28.4077	9.3102	2.90687
808	2538.4	512758	652864	527514112	28.4253	9.3140	2.90741
809	2541.5	514028	654481	529475129	28.4429	9.3179	2.90795
810	2544.7	515300	656100	531441000	28.4605	9.3217	2.90849
811	2547.8	516573	657721	533411731	28.4781	9.3255	2.90902
812	2551.0	517848	659344	535387328	28.4956	9.3294	2.90956
813	2554.1	519124	660969	537367797	28.5132	9.3332	2.91009
814	2557.3	520402	662596	539353144	28.5307	9.3370	2.91062
815	2560.4	521681	664225	541343375	28.5482	9.3408	2.91116
816	2563.5	522962	665856	543338496	28.5657	9.3447	2.91169
817	2566.7	524245	667489	545338513	28.5832	9.3485	2.91222
818	2569.8	525529	669124	547343432	28.6007	9.3523	2.91275
819	2573.0	526814	670761	549353259	28.6182	9.3561	2.91328
820	2576.1	528102	672400	551368000	28.6356	9.3599	2.91381
821	2579.2	529391	674041	553387661	28.6531	9.3637	2.91434
822	2582.4	530681	675684	555412248	28.6705	9.3675	2.91487
823	2585.5	531973	677329	557441767	28.6880	9.3713	2.91540
824	2588.7	533267	678976	559476224	28.7054	9.3751	2.91593
825	2591.8	534562	680625	561515625	28.7228	9.3789	2.91645
826	2595.0	535858	682276	563559976	28.7402	9.3827	2.91698
827	2598.1	537157	683929	565609283	28.7576	9.3865	2.91751
828	2601.2	538456	685584	567663552	28.7750	9.3902	2.91803
829	2604.4	539758	687241	569722789	28.7924	9.3940	2.91855
830	2607.5	541061	688900	571787000	28.8097	9.3978	2.91908
831	2610.7	542365	690561	573856191	28.8271	9.4016	2.91960
832	2613.8	543671	692224	575930368	28.8444	9.4053	2.92012
833	2616.9	544979	693889	578009537	28.8617	9.4091	2.92065
834	2620.1	546288	695556	580093704	28.8791	9.4129	2.92117
835	2623.2	547599	697225	582182875	28.8964	9.4166	2.92169
836	2626.4	548912	698896	584277056	28.9137	9.4204	2.92221
837	2629.5	550226	700569	586376253	28.9310	9.4241	2.92273
838	2632.7	551541	702244	588480472	28.9482	9.4279	2.92324
839	2635.8	552858	703921	590589719	28.9655	9.4316	2.92376
840	2638.9	554177	705600	592704000	28.9828	9.4354	2.92428
841	2642.1	555497	707281	594823321	29.0000	9.4391	2.92480
842	2645.2	556819	708964	596947688	29.0172	9.4429	2.92531
843	2648.4	558142	710649	599077107	29.0345	9.4466	2.92583
844	2651.5	559467	712336	601211584	29.0517	9.4503	2.92634
845	2654.6	560794	714025	603351125	29.0689	9.4541	2.92686
846	2657.8	562122	715716	605495736	29.0861	9.4578	2.92737
847	2660.9	563452	717409	607645423	29.1033	9.4615	2.92788
848	2664.1	564783	719104	609800192	29.1204	9.4652	2.92840
849	2667.2	566116	720801	611960049	29.1376	9.4690	2.92891

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
850	2670.4	567450	722500	614125000	29.1548	9.4727	2.92942
851	2673.5	568786	724201	616295051	29.1719	9.4764	2.92993
852	2676.6	570124	725904	618470208	29.1890	9.4801	2.93044
853	2679.8	571463	727609	620650477	29.2062	9.4838	2.93095
854	2682.9	572803	729316	622835864	29.2233	9.4875	2.93146
855	2686.1	574146	731025	625026375	29.2404	9.4912	2.93197
856	2689.2	575490	732736	627222016	29.2575	9.4949	2.93247
857	2692.3	576835	734449	629422793	29.2746	9.4986	2.93298
858	2695.5	578182	736164	631628712	29.2916	9.5023	2.93349
859	2698.6	579530	737881	633839779	29.3087	9.5060	2.93399
860	2701.8	580880	739600	636056000	29.3258	9.5097	2.93450
861	2704.9	582232	741321	638277381	29.3428	9.5134	2.93500
862	2708.1	583585	743044	640503928	29.3598	9.5171	2.93551
863	2711.2	584940	744769	642735647	29.3769	9.5207	2.93601
864	2714.3	586297	746496	644972544	29.3939	9.5244	2.93651
865	2717.5	587655	748225	647214625	29.4109	9.5281	2.93702
866	2720.6	589014	749956	649461896	29.4279	9.5317	2.93752
867	2723.8	590375	751689	651714363	29.4449	9.5354	2.93802
868	2726.9	591738	753424	653972032	29.4618	9.5391	2.93852
869	2730.0	593102	755161	656234909	29.4788	9.5427	2.93902
870	2733.2	594468	756900	658503000	29.4958	9.5464	2.93952
871	2736.3	595835	758641	660776311	29.5127	9.5501	2.94002
872	2739.5	597204	760384	663054848	29.5296	9.5537	2.94052
873	2742.6	598575	762129	665338617	29.5466	9.5574	2.94101
874	2745.8	599947	763876	667627624	29.5635	9.5610	2.94151
875	2748.9	601320	765625	669921875	29.5804	9.5647	2.94201
876	2752.0	602696	767376	672221376	29.5973	9.5683	2.94250
877	2755.2	604073	769129	674526133	29.6142	9.5719	2.94300
878	2758.3	605451	770884	676836152	29.6311	9.5756	2.94349
879	2761.5	606831	772641	679151439	29.6479	9.5792	2.94399
880	2764.6	608212	774400	681472000	29.6648	9.5828	2.94448
881	2767.7	609595	776161	683797841	29.6816	9.5865	2.94498
882	2770.9	610980	777924	686128968	29.6985	9.5901	2.94547
883	2774.0	612366	779689	688465387	29.7153	9.5937	2.94596
884	2777.2	613754	781456	690807104	29.7321	9.5973	2.94645
885	2780.3	615143	783225	693154125	29.7489	9.6010	2.94694
886	2783.5	616534	784996	695506456	29.7658	9.6046	2.94743
887	2786.6	617927	786769	697864103	29.7825	9.6082	2.94792
888	2789.7	619321	788544	700227072	29.7993	9.6118	2.94841
889	2792.9	620717	790321	702595369	29.8161	9.6154	2.94890
890	2796.0	622114	792100	704969000	29.8329	9.6190	2.94939
891	2799.2	623513	793881	707347971	29.8496	9.6226	2.94988
892	2802.3	624913	795664	709732288	29.8664	9.6262	2.95036
893	2805.4	626315	797449	712121957	29.8831	9.6298	2.95085
894	2808.6	627718	799236	714516984	29.8998	9.6334	2.95134
895	2811.7	629124	801025	716917375	29.9166	9.6370	2.95182
896	2814.9	630530	802816	719323136	29.9333	9.6406	2.95231
897	2818.0	631938	804609	721734273	29.9500	9.6442	2.95279
898	2821.2	633348	806404	724150792	29.9666	9.6477	2.95328
899	2824.3	634760	808201	726572699	29.9833	9.6513	2.95376

Functions of Numbers

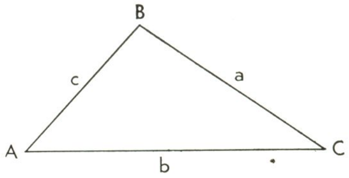
AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
900	2827.4	636173	810000	729000000	30.0000	9.6549	2.95424
901	2830.6	637587	811801	731432701	30.0167	9.6585	2.95472
902	2833.7	639003	813604	733870808	30.0333	9.6620	2.95521
903	2836.9	640421	815409	736314327	30.0500	9.6656	2.95569
904	2840.0	641840	817216	738763264	30.0666	9.6692	2.95617
905	2843.1	643261	819025	741217625	30.0832	9.6727	2.95665
906	2846.3	644683	820836	743677416	30.0998	9.6763	2.95713
907	2849.4	646107	822649	746142643	30.1164	9.6799	2.95761
908	2852.6	647533	824464	748613312	30.1330	9.6834	2.95809
909	2855.7	648960	826281	751089429	30.1496	9.6870	2.95856
910	2858.8	650388	828100	753571000	30.1662	9.6905	2.95904
911	2862.0	651818	829921	756058031	30.1828	9.6941	2.95952
912	2865.1	653250	831744	758550528	30.1993	9.6976	2.95999
913	2868.3	654684	833569	761048497	30.2159	9.7012	2.96047
914	2871.4	656118	835396	763551944	30.2324	9.7047	2.96095
915	2874.6	657555	837225	766060875	30.2490	9.7082	2.96142
916	2877.7	658993	839056	768575296	30.2655	9.7118	2.96190
917	2880.8	660433	840889	771095213	30.2820	9.7153	2.96237
918	2884.0	661874	842724	773620632	30.2985	9.7188	2.96284
919	2887.1	663317	844561	776151559	30.3150	9.7224	2.96332
920	2890.3	664761	846400	778688000	30.3315	9.7259	2.96379
921	2893.4	666207	848241	781229961	30.3480	9.7294	2.96426
922	2896.5	667654	850084	783777448	30.3645	9.7329	2.96473
923	2899.7	669103	851929	786330467	30.3809	9.7364	2.96520
924	2902.8	670554	853776	788889024	30.3974	9.7400	2.96567
925	2906.0	672006	855625	791453125	30.4138	9.7435	2.96614
926	2909.1	673460	857476	794022776	30.4302	9.7470	2.96661
927	2912.3	674915	859329	796597983	30.4467	9.7505	2.96708
928	2915.4	676372	861184	799178752	30.4631	9.7540	2.96755
929	2918.5	677831	863041	801765089	30.4795	9.7575	2.96802
930	2921.7	679291	864900	804357000	30.4959	9.7610	2.96848
931	2924.8	680752	866761	806954491	30.5123	9.7645	2.96895
932	2928.0	682216	868624	809557568	30.5287	9.7680	2.96942
933	2931.1	683680	870489	812166237	30.5450	9.7715	2.96988
934	2934.2	685147	872356	814780504	30.5614	9.7750	2.97035
935	2937.4	686615	874225	817400375	30.5778	9.7785	2.97081
936	2940.5	688084	876096	820025856	30.5941	9.7819	2.97128
937	2943.7	689555	877969	822656953	30.6105	9.7854	2.97174
938	2946.8	691028	879844	825293672	30.6268	9.7889	2.97220
939	2950.0	692502	881721	827936019	30.6431	9.7924	2.97267
940	2953.1	693978	883600	830584000	30.6594	9.7959	2.97313
941	2956.2	695455	885481	833237621	30.6757	9.7993	2.97359
942	2959.4	696934	887364	835896888	30.6920	9.8028	2.97405
943	2962.5	698415	889249	838561807	30.7083	9.8063	2.97451
944	2965.7	699897	891136	841232384	30.7246	9.8097	2.97497
945	2968.8	701380	893025	843908625	30.7409	9.8132	2.97543
946	2971.9	702865	894916	846590536	30.7571	9.8167	2.97589
947	2975.1	704352	896809	849278123	30.7734	9.8201	2.97635
948	2978.2	705840	898704	851971392	30.7896	9.8236	2.97681
949	2981.4	707330	900601	854670349	30.8058	9.8270	2.97727

Functions of Numbers

AREA, CIRCUMFERENCE, SQUARE, CUBE, SQUARE AND CUBE ROOTS, AND COMMON LOGARITHMS

No.	No. = Diameter		Square	Cube	Square Root	Cube Root	Logarithm
	Circum.	Area					
950	2984.5	708822	902500	857375000	30.8221	9.8305	2.97772
951	2987.7	710315	904401	860085351	30.8383	9.8339	2.97818
952	2990.8	711809	906304	862801408	30.8545	9.8374	2.97864
953	2993.9	713306	908209	865523177	30.8707	9.8408	2.97909
954	2997.1	714803	910116	868250664	30.8869	9.8443	2.97955
955	3000.2	716303	912025	870983875	30.9031	9.8477	2.98000
956	3003.4	717804	913936	873722816	30.9192	9.8511	2.98046
957	3006.5	719306	915849	876467493	30.9354	9.8546	2.98091
958	3009.6	720810	917764	879217912	30.9516	9.8580	2.98137
959	3012.8	722316	919681	881974079	30.9677	9.8614	2.98182
960	3015.9	723823	921600	884736000	30.9839	9.8648	2.98227
961	3019.1	725332	923521	887503681	31.0000	9.8683	2.98272
962	3022.2	726842	925444	890277128	31.0161	9.8717	2.98318
963	3025.4	728354	927369	893056347	31.0322	9.8751	2.98363
964	3028.5	729867	929296	895841344	31.0483	9.8785	2.98408
965	3031.6	731382	931225	898632125	31.0644	9.8819	2.98453
966	3034.8	732899	933156	901428696	31.0805	9.8854	2.98498
967	3037.9	734417	935089	904231063	31.0966	9.8888	2.98543
968	3041.1	735937	937024	907039232	31.1127	9.8922	2.98588
969	3044.2	737458	938961	909853209	31.1288	9.8956	2.98632
970	3047.3	738981	940900	912673000	31.1448	9.8990	2.98677
971	3050.5	740506	942841	915498611	31.1609	9.9024	2.98722
972	3053.6	742032	944784	918330048	31.1769	9.9058	2.98767
973	3056.8	743559	946729	921167317	31.1929	9.9092	2.98811
974	3059.9	745088	948676	924010424	31.2090	9.9126	2.98856
975	3063.1	746619	950625	926859375	31.2250	9.9160	2.98900
976	3066.2	748151	952576	929714176	31.2410	9.9194	2.98945
977	3069.3	749685	954529	932574833	31.2570	9.9227	2.98989
978	3072.5	751221	956484	935441352	31.2730	9.9261	2.99034
979	3075.6	752758	958441	938313739	31.2890	9.9295	2.99078
980	3078.8	754296	960400	941192000	31.3050	9.9329	2.99123
981	3081.9	755837	962361	944076141	31.3209	9.9363	2.99167
982	3085.0	757378	964324	946966168	31.3369	9.9396	2.99211
983	3088.2	758922	966289	949862087	31.3528	9.9430	2.99255
984	3091.3	760466	968256	952763904	31.3688	9.9464	2.99300
985	3094.5	762013	970225	955671625	31.3847	9.9497	2.99344
986	3097.6	763561	972196	958585256	31.4006	9.9531	2.99388
987	3100.8	765111	974169	961504803	31.4166	9.9565	2.99432
988	3103.9	766662	976144	964430272	31.4325	9.9598	2.99476
989	3107.0	768214	978121	967361669	31.4484	9.9632	2.99520
990	3110.2	769769	980100	970299000	31.4643	9.9666	2.99564
991	3113.3	771325	982081	973242271	31.4802	9.9699	2.99607
992	3116.5	772882	984064	976191488	31.4960	9.9733	2.99651
993	3119.6	774441	986049	979146657	31.5119	9.9766	2.99695
994	3122.7	776002	988036	982107784	31.5278	9.9800	2.99739
995	3125.9	777564	990025	985074875	31.5436	9.9833	2.99782
996	3129.0	779128	992016	988047936	31.5595	9.9866	2.99826
997	3132.2	780693	994009	991026973	31.5753	9.9900	2.99870
998	3135.3	782260	996004	994011992	31.5911	9.9933	2.99913
999	3138.5	783828	998001	997002999	31.6070	9.9967	2.99957



Solution of Oblique Triangles

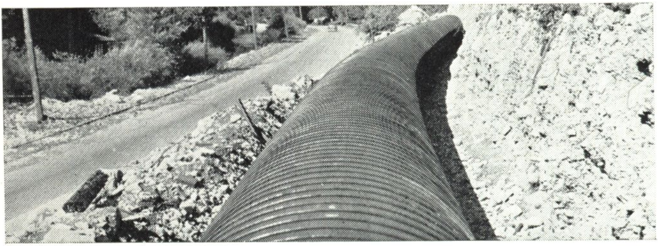
TO FIND a, b, c

Given	Formulae	Given	Formulae
A, B, b	$a = \frac{b \sin A}{\sin B}$	C, c, a	$\sin A = \frac{a \sin C}{c}$
A, B, a	$b = \frac{a \sin B}{\sin A}$	A, a, b	$\sin B = \frac{b \sin A}{a}$
A, C, a	$c = \frac{a \sin C}{\sin A}$	A, c, a	$\sin C = \frac{c \sin A}{a}$

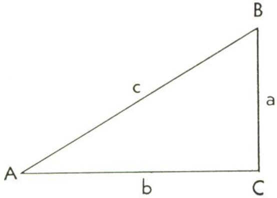
TO FIND A, B, C

Given	Formulae
b, c, s	$\sin \frac{1}{2} A = \sqrt{\frac{(s-c)\ (s-b)}{bc}}$
a, c, s	$\sin \frac{1}{2} B = \sqrt{\frac{(s-c)\ (s-a)}{ac}}$
a, b, s	$\sin \frac{1}{2} C = \sqrt{\frac{(s-a)\ (s-b)}{ab}}$

$s = \frac{1}{2}(a + b + c)$



"National Quality" Creosoted Douglas Fir Pipe



Solution of Right Triangles

TO FIND A

Given	Formulae	Given	Formulae
a, b	$\tan A = \frac{a}{b}$	a, b	$\cot A = \frac{b}{a}$
a, c	$\sin A = \frac{a}{c}$	b, c	$\cos A = \frac{b}{c}$

TO FIND B

a, b	$\cot B = \frac{a}{b}$	a, b	$\tan B = \frac{b}{a}$
a, c	$\cos B = \frac{a}{c}$	b, c	$\sin B = \frac{b}{c}$

TO FIND a

A, b	$a = b \tan A$	B, c	$a = c \cos B$
A, c	$a = c \sin A$	B, b	$a = b \cot B$

TO FIND b

A, c	$b = c \cos A$	B, c	$b = c \sin B$
A, a	$b = a \cot A$	B, a	$b = a \tan B$

TO FIND c

A, a	$c = \frac{a}{\sin A}$	B, a	$c = \frac{a}{\cos B}$
A, b	$c = \frac{b}{\cos A}$	B, b	$c = \frac{b}{\sin B}$

Trigonometric Functions next page

Trigonometric Functions

and their common logarithms

Angle	SINE Natural	SINE Log	TANGENT Natural	TANGENT Log	COTANGENT Natural	COTANGENT Log	COSINE Natural	COSINE Log	
0°	.0000	.....	.0000	.....	.....	.....	1.0000	0.0000	90°
1°	.0175	8.2419	.0175	8.2419	57.290	1.7581	.9999	9.9999	89°
2°	.0349	8.5428	.0349	8.5431	28.636	1.4569	.9994	9.9997	88°
3°	.0523	8.7188	.0524	8.7194	19.081	1.2806	.9986	9.9994	87°
4°	.0698	8.8436	.0699	8.8446	14.301	1.1554	.9976	9.9989	86°
5°	.0872	8.9403	.0875	8.9420	11.430	1.0580	.9962	9.9983	85°
6°	.1045	9.0192	.1051	9.0216	9.5144	0.9784	.9945	9.9976	84°
7°	.1219	9.0859	.1228	9.0891	8.1444	0.9109	.9926	9.9968	83°
8°	.1392	9.1436	.1405	9.1478	7.1154	0.8522	.9903	9.9958	82°
9°	.1564	9.1943	.1584	9.1997	6.3138	0.8003	.9877	9.9946	81°
10°	.1737	9.2397	.1763	9.2463	5.6713	0.7537	.9848	9.9934	80°
11°	.1908	9.2806	.1944	9.2887	5.1446	0.7113	.9816	9.9919	79°
12°	.2079	9.3179	.2126	9.3275	4.7046	0.6725	.9782	9.9904	78°
13°	.2250	9.3521	.2309	9.3634	4.3315	0.6366	.9744	9.9887	77°
14°	.2419	9.3837	.2493	9.3968	4.0108	0.6032	.9703	9.9869	76°
15°	.2588	9.4130	.2680	9.4281	3.7321	0.5719	.9659	9.9849	75°
16°	.2756	9.4403	.2868	9.4575	3.4874	0.5425	.9613	9.9828	74°
17°	.2924	9.4659	.3057	9.4853	3.2709	0.5147	.9563	9.9806	73°
18°	.3090	9.4900	.3249	9.5118	3.0777	0 4882	.9511	9.9782	72°
19°	.3256	9.5126	.3443	9.5370	2.9042	0.4630	.9455	9.9757	71°
20°	.3420	9.5341	.3640	9.5611	2.7475	0.4389	.9397	9.9730	70°
21°	.3584	9.5543	.3839	9.5842	2.6051	0.4158	.9336	9.9702	69°
22°	.3746	9.5736	.4040	9.6064	2.4751	0.3936	.9272	9.9672	68°
23°	.3907	9.5919	.4245	9.6279	2.3559	0.3721	.9205	9.9640	67°
24°	.4067	9.6093	.4452	9.6486	2.2460	0.3514	.9136	9.9607	66°
25°	.4226	9.6259	.4663	9.6687	2.1445	0.3313	.9063	9.9573	65°
26°	.4384	9.6418	.4877	9.6882	2.0503	0.3118	.8988	9.9537	64°
27°	.4540	9.6570	.5095	9.7072	1.9626	0.2928	.8910	9.9499	63°
28°	.4695	9.6716	.5317	9.7257	1.8807	0.2743	.8830	9.9459	62°
29°	.4848	9.6856	.5543	9.7438	1.8041	0.2562	.8746	9.9418	61°
30°	.5000	9.6990	.5774	9.7614	1.7321	0.2386	.8660	9.9375	60°
31°	.5150	9.7118	.6009	9.7788	1.6643	0.2212	.8572	9.9331	59°
32°	.5299	9.7242	.6249	9.7958	1.6003	0.2042	.8481	9.9284	58°
33°	.5446	9.7361	.6494	9.8125	1.5399	0.1875	.8387	9.9236	57°
34°	.5592	9.7476	.6745	9.8290	1.4826	0.1710	.8290	9.9186	56°
35°	.5736	9.7586	.7002	9.8452	1.4282	0.1548	.8192	9.9134	55°
36°	.5878	9.7692	.7265	9.8613	1.3764	0.1387	.8090	9.9080	54°
37°	.6018	9.7795	.7536	9.8771	1.3270	0.1229	.7986	9.9023	53°
38°	.6157	9.7893	.7813	9.8928	1.2799	0.1072	.7880	9.8965	52°
39°	.6293	9.7989	.8098	9.9084	1.2349	0.0916	.7772	9.8905	51°
40°	.6428	9.8081	.8391	9.9238	1.1918	0.0762	.7660	9.8843	50°
41°	.6561	9.8169	.8693	9.9392	1.1504	0.0608	.7547	9.8778	49°
42°	.6691	9.8255	.9004	9.9544	1.1106	0.0456	.7431	9.8711	48°
43°	.6820	9.8338	.9325	9.9697	1.0724	0.0303	.7314	9.8641	47°
44°	.6947	9.8418	.9657	9.9848	1.0355	0.0152	.7193	9.8569	46°
45°	.7071	9.8495	1.0000	0.0000	1.0000	0.0000	.7071	9.8495	45°
	Natural COSINE	Log COSINE	Natural COTANGENT	Log COTANGENT	Natural TANGENT	Log TANGENT	Natural SINE	Log SINE	Angle

Note: log sec x = —log cos x. Log sec x = —log sin x.

Square Roots of Decimal Numbers

For Use in Manning's Formula

No.	.—0	.—1	.—2	.—3	.—4	.—5	.—6	.—7	.—8	.—9
.00001	.003162	.003317	.003464	.003606	.003742	.003873	.004000	.004123	.004243	.004359
.00002	.004472	.004583	.004690	.004796	.004899	.005000	.005099	.005196	.005292	.005385
.00003	.005477	.005568	.005657	.005745	.005831	.005916	.006000	.006083	.006164	.006245
.00004	.006325	.006403	.006481	.006557	.006633	.006708	.006782	.006856	.006928	.007000
.00005	.007071	.007141	.007211	.007280	.007348	.007416	.007483	.007550	.007616	.007681
.00006	.007746	.007810	.007874	.007937	.008000	.008062	.008124	.008185	.008246	.008307
.00007	.008367	.008426	.008485	.008544	.008602	.008660	.008718	.008775	.008832	.008888
.00008	.008944	.009000	.009055	.009110	.009165	.009220	.009274	.009327	.009381	.009434
.00009	.009487	.009539	.009592	.009644	.009695	.009747	.009798	.009849	.009899	.009950
.00010	.010000	.010050	.010100	.010149	.010198	.010247	.010296	.010344	.010392	.010440
.0001	.01000	.01049	.01095	.01140	.01183	.01225	.01265	.01304	.01342	.01378
.0002	.01414	.01449	.01483	.01517	.01549	.01581	.01612	.01643	.01673	.01703
.0003	.01732	.01761	.01789	.01817	.01844	.01871	.01897	.01924	.01949	.01975
.0004	.02000	.02025	.02049	.02074	.02098	.02121	.02145	.02168	.02191	.02214
.0005	.02236	.02258	.02280	.02302	.02324	.02345	.02366	.02387	.02408	.02429
.0006	.02449	.02470	.02490	.02510	.02530	.02550	.02569	.02588	.02608	.02627
.0007	.02646	.02665	.02683	.02702	.02720	.02739	.02757	.02775	.02793	.02811
.0008	.02828	.02846	.02864	.02881	.02898	.02915	.02933	.02950	.02966	.02983
.0009	.03000	.03017	.03033	.03050	.03066	.03082	.03098	.03114	.03130	.03146
.0010	.03162	.03178	.03194	.03209	.03225	.03240	.03256	.03271	.03286	.03302
.001	.03162	.03317	.03464	.03606	.03742	.03873	.04000	.04123	.04243	.04359
.002	.04472	.04583	.04690	.04796	.04899	.05000	.05099	.05196	.05292	.05385
.003	.05477	.05568	.05657	.05745	.05831	.05916	.06000	.06083	.06164	.06245
.004	.06325	.06403	.06481	.06557	.06633	.06708	.06782	.06856	.06928	.07000
.005	.07071	.07141	.07211	.07280	.07348	.07416	.07483	.07550	.07616	.07681
.006	.07746	.07810	.07874	.07937	.08000	.08062	.08124	.08185	.08246	.08307
.007	.08367	.08426	.08485	.08544	.08602	.08660	.08718	.08775	.08832	.08888
.008	.08944	.09000	.09055	.09110	.09165	.09220	.09274	.09327	.09381	.09434
.009	.09487	.09539	.09592	.09644	.09695	.09747	.09798	.09849	.09899	.09950
.010	.10000	.10050	.10100	.10149	.10198	.10247	.10296	.10344	.10392	.10440
.01	.1000	.1049	.1095	.1140	.1183	.1225	.1265	.1304	.1342	.1378
.02	.1414	.1449	.1483	.1517	.1549	.1581	.1612	.1643	.1673	.1703
.03	.1732	.1761	.1789	.1817	.1844	.1871	.1897	.1924	.1949	.1975
.04	.2000	.2025	.2049	.2074	.2098	.2121	.2145	.2168	.2191	.2214
.05	.2236	.2258	.2280	.2302	.2324	.2345	.2366	.2387	.2408	.2429
.06	.2449	.2470	.2490	.2510	.2530	.2550	.2569	.2588	.2608	.2627
.07	.2646	.2665	.2683	.2702	.2720	.2739	.2757	.2775	.2793	.2811
.08	.2828	.2846	.2864	.2881	.2898	.2915	.2933	.2950	.2966	.2983
.09	.3000	.3017	3033	.3050	.3066	.3082	.3098	.3114	.3130	.3146
.10	.3162	.3178	.3194	.3209	.3225	.3240	.3256	.3271	.3286	.3302

EXCAVATION TABLE

Giving cubic yards excavated from 100 feet of various widths and depths of trench

Depth of Trench in Inches	Width of Trench in Inches																	
	12	14	16	18	20	24	30	36	42	48	54	60	66	72	78	84	90	96
12	3.70	4.32	4.94	5.56	6.17	7.41	9.26	11.11	12.96	14.80	16.67	18.52	20.37	22.22	24.07	25.92	27.77	29.63
14	4.32	5.04	5.76	6.48	7.20	8.64	10.80	12.96	15.12	17.28	19.44	21.60	23.76	25.92	28.08	30.24	32.40	34.56
16	4.94	5.76	6.58	7.41	8.23	9.88	12.35	14.81	17.28	19.75	22.22	24.69	27.16	29.63	32.10	34.57	37.03	39.50
18	5.56	6.48	7.41	8.33	9.26	11.11	13.88	16.67	19.44	22.22	25.00	27.78	30.56	33.33	36.11	38.89	41.67	44.44
20	6.17	7.20	8.23	9.26	10.29	12.35	15.43	18.52	21.60	24.69	27.78	30.87	33.95	37.04	40.12	43.21	46.30	49.38
24	7.41	8.64	9.88	11.11	12.35	14.81	18.52	22.22	25.93	29.63	33.33	37.04	40.74	44.44	48.15	51.85	55.56	59.26
30	9.26	10.80	12.35	13.88	15.43	18.52	23.15	27.78	32.41	37.04	41.67	46.30	50.93	55.55	60.19	64.81	69.44	74.07
36	11.11	12.96	14.81	16.67	18.52	22.22	27.78	33.33	38.89	44.44	50.00	55.55	61.11	66.67	72.22	77.78	83.33	88.89
42	12.96	15.12	17.28	19.44	21.60	25.93	32.41	38.87	45.37	51.85	58.33	64.81	71.30	77.78	84.26	90.74	97.22	103.70
48	14.80	17.28	19.75	22.22	24.69	29.63	37.04	44.42	51.85	59.26	66.67	74.07	81.48	88.89	96.30	103.70	111.11	118.52
54	16.67	19.44	22.22	25.00	27.78	33.33	41.67	50.00	58.33	66.67	75.00	83.33	91.67	100.00	108.33	116.67	125.00	133.33
60	18.52	21.60	24.69	27.78	30.87	37.04	46.30	55.55	64.81	74.07	83.33	92.59	101.85	111.11	120.37	129.63	138.89	148.15
66	20.37	23.76	27.16	30.56	33.95	40.74	50.93	61.11	71.30	81.48	91.67	101.85	112.04	122.22	132.41	142.59	152.78	162.96
72	22.22	25.92	29.63	33.33	37.04	44.44	55.55	66.67	77.78	88.89	100.00	111.11	122.22	133.33	144.44	155.56	166.67	177.78
78	24.07	28.08	32.10	36.11	40.12	48.15	60.19	72.22	84.26	96.30	108.33	120.37	132.41	144.44	156.48	168.52	180.56	192.59
84	25.92	30.24	34.56	38.89	43.21	51.85	64.81	77.78	90.74	103.70	116.67	129.63	142.59	155.56	168.52	181.48	194.44	207.41
90	27.77	32.40	37.03	41.67	46.30	55.56	69.45	83.33	97.22	111.11	125.00	138.89	152.78	166.67	180.56	194.44	208.33	222.22
96	29.63	34.56	39.50	44.44	49.38	59.26	74.08	88.89	103.70	118.52	133.33	148.15	162.96	177.78	192.59	207.41	222.22	237.04
102	31.48	36.72	41.98	47.22	52.47	62.96	78.71	94.44	110.19	125.93	141.67	157.41	173.15	188.89	204.61	220.37	236.11	251.85
108	33.33	38.88	44.44	50.00	55.56	66.67	83.34	100.00	116.67	133.33	150.00	166.67	183.33	200.00	216.67	233.33	250.00	266.67
114	35.19	41.04	46.91	52.78	58.64	70.37	87.97	105.56	123.15	140.74	158.33	175.93	193.52	211.11	228.70	246.30	263.89	281.48
120	37.04	43.21	49.38	55.56	61.73	74.07	92.60	111.11	129.63	148.15	166.67	185.19	203.71	222.22	240.74	259.26	277.78	296.30

Example: A trench 48″ deep and 60″ wide will require 74.07 cubic yards of excavation.

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